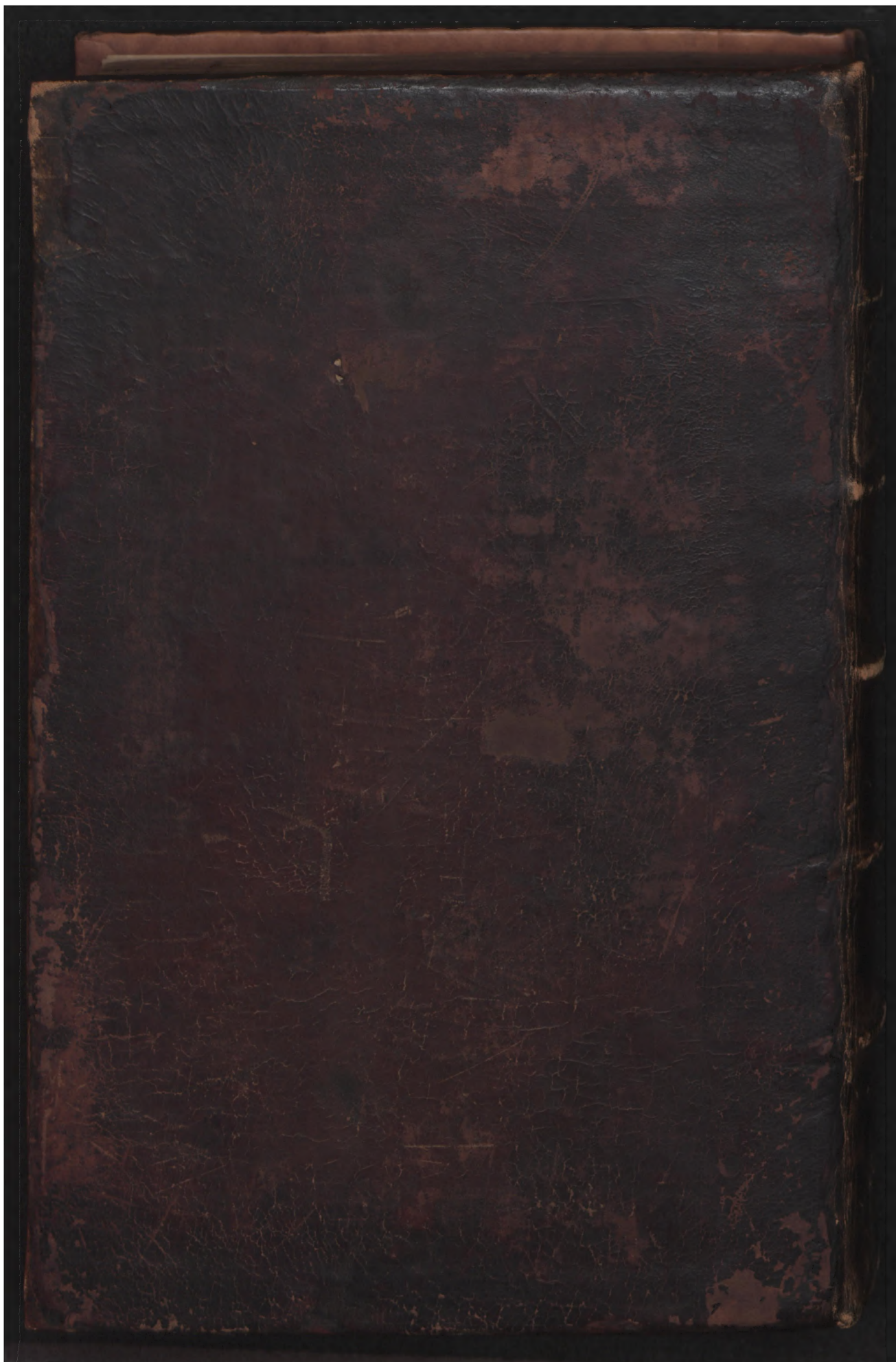




Early European Books, Copyright © 2010 ProQuest LLC.
Images reproduced by courtesy of the Royal Library, Copenhagen.
2* K.B. 9,163





Early European Books, Copyright © 2010 ProQuest LLC.
Images reproduced by courtesy of the Royal Library, Copenhagen.
2^o K.B. 9,163



Early European Books, Copyright © 2010 ProQuest LLC.
Images reproduced by courtesy of the Royal Library, Copenhagen.
2° K.B. 9,163



Early European Books, Copyright © 2010 ProQuest LLC.
Images reproduced by courtesy of the Royal Library, Copenhagen.
2" K.B. 9.163

9, 163

UNIVERSITETSBIBLIOTEKET 2. AFD.
2° KB 9

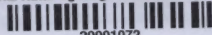


2 1 009 0 00024 X

OVERFØRT
fra
DET KONGELIGE BIBLIOTEK
til
UNIVERSITETSBIBLIOTEKET



Danmarks Natur-og Lægevidenskabelige Bibliotek



20001072

MATHEMATICAL

Collections *and* Translations:

In two

T O M E S.

MATHEMATICAL

Collected and Translated

by

TOMES

MATHEMATICAL
COLLECTIONS
AND
TRANSLATIONS.

THE FIRST
TOME.


THE FIRST PART;

Containing,

- I. GALILEUS GALILEUS, *His SYSTEME of the World.*
- II. GALILEUS, *his EPISTLE to the GRAND DUTCHESSE Mother concerning the Authority of Sacred SCRIPTURE in Philosophical Controversies.*
- III. JOHANNES KEPLERUS, *his Reconcilings of SCRIPTURE Texts, &c.*
- IV. DIDACUS a STUNICA, *his Reconcilings of SCRIPTURE Texts, &c.*
- V. P. A. FOSCARINUS, *his Epistle to Father FANTONUS, reconciling the Authority of Sacred SCRIPTURE, and Judgments of Divines alledged against, &c.*

By THOMAS SALUSBURY, Esq.

LONDON,
Printed by WILLIAM LEYBOURNE, MDCLXI.





To the Noble and most perfectly Accomplished
Sr. JOHN DENHAM
Knight of the Noble Order of the
BATH,

And Surveyor General of his Ma^{ties} Works, &c.

SIR,



Humbly begge your Pardon for bringing this Book under your Protection. Were it a VVork of my own, or I any thing but the Transla-
tour, I should master my Thoughts to a meaner Dedication; But being a Collection of some of the greatest Masters in the VVorld, and never made English till now, I conceived I might sooner procure their VVelcome to a person so eminent for Noble Candor, as well as for all those Intellectual Excellencies wherewith Your Rich Soul is known to be furnished. I resolv'd to be as kind to this Book as I could,
and

and seriously considering which way to effect
it , I at last concluded to prefix Your Name,
whom His Majesty and all his Subjects, (who
have a higher Sense and Judgement of Excel-
lent Parts) know best able to defend my Im-
perfections. And yet I confess there's one
thing makes against me, which is your eminent
Integrity and great Affection to Truth, where-
by my Lapses in a VVork of this Nature might
justly despair of Shelter, but that the Excel-
lency of Your Native Candor strives for Pre-
dominancy over all Your great Abilities. For
'tis all-most impossible to think what Your
Matchless VVit is not able to Conquer, would
Your known Modesty but give leave: there-
fore *Galileus, Kepler*, and those other Worthies
in Learning are now brought before You in
English Habit, having chang'd their Latine,
Italian and French, whereby they were almost
Strangers to our Nation, unless to such as You,
who so perfectly master the Originals. I know
you have so much and great imployment for
His Majesty, and his good Subjects that I shall
not robb you of another Minutes loss; besides
the liberty of subscribing my Self;

S I R,

Your Honour

Most humble
and
Most obedient Servant

THOMAS SALUSBURY.

READER,

Mathematical Learning (to speak nothing touching the necessity & delight thereof) hath bin so sparingly imparted to our Countrymen in their native English, especially the nobler and sublimer part, that in Compliance with the Solicitations of several of my noble and learned Friends, and the Inclinations of such as are Mathematically disposed, more especially those, who either want Time or Patience to look into the vulgar and unstudied Languages, I did adventure upon this Work of Collecting & Translating from amongst the excellent Pieces that are so abounding in the Italian and French Tongues, some of those that my own observation and the intimation of Friends were most usefull and desired, and with all most wanting in their Own.

I was, indeed, at first seriously Conscious, and am now, by experience, fully convinced how disproportionate the weight of the Enterprize is to the weakness of the Undertaker, but yet the Passion I ever had to be subservient to my Friends and Compatriots in their Inquisition after these Sublime Studies, and a Patience which I owe to the Flegme that is predominant in my Constitution, joyed with a nine-years converse in these Languages, as also an unhappy and long Vacation that the persecutions of the late Tyrants gave me from more advantageous employments so prevailed with me, that I resolved to improve even my very Confinement to serve those Friends, whom, as the Times then stood, I could not see.

The Book being for Subject and Design intended chiefly for Gentlemen, I have bin as careless of using a studied Pedantry in my Style; as careful in contriving a pleasant and beautiful Impression. And when I had considered the hazard, and computed the charge of the undertaking, I found it to exceed the ability of a private Person, especially of mine, that had bin so lately emptied by the hand of violent enemies, and perfidious friends; nor to make mention here of the Sums that a Loyal Reflexion upon my Princes Affairs had at the same time drawn from me; and judg'd that the most safe, easy, and reasonable way was to invite those Persons who had appeared zealous of the Book, to be contributory to their own Contentment, by subscribing towards the charge of this Publication.

And for the better management of the Work, I joyned to my self a Printer, whose Genius having rendered him Mathematical, and my overtures of profit having interess'd his diligence, I was induc'd to promise my self a more than common Assistance from him; and at his door I with reason lay all misadventures that concern his Profession in the Business.

In this work I received extraordinary Encouragement from that publick spirited Person the Reverend and Learned Dr. Thomas Barlow, Provost of Queens College in Oxford, and Margaret Professor in that University, as also from those two able Mathematicians and my Real Friends, Mr. Miles Symmer, and Mr. Robert Wood of Trinity Colledge Dublin, and some few others whose Modesty hath exprestly join'd me a concealment of their Names.

Well, at length I have got to the end of my first Stage; and if I have not rid Post, let my excuse be that my long stay for my warrant caused me to set out late; and being ill mounted, and in a road full of rubbs, I could not with any safety go faster; but hope to get it up in the next Stage, for in that I intend to shift my Horses.

The names of those Authors and Treatises which I judg'd would most grace our Language, and gratify Students, are particularly exprest in the General Title of the two Tomes. Distinct Tomes they are as consisting of several Pieces: Collections I call them, because they have bin so published, dispers'd, and worn out of Print, that they very rarely meet in one hand: and Translations I own them to be, as not pretending to any thing more than the disposure and conversion of them: those Traicts only excepted, which compose the second Part of the second Tome.

The first Book, which offers it self to your view in this Tome is that singular and unimitable Piece of Reason and Demonstration the Systeme of Galileo. The subject of it is a new and Noble part of Astronomy, to wit the Doctrine and Hypothesis of the Mobility of the Earth and the Stability of the Sun; the History whereof I shall hereafter give you at large in the Life of that famous Man. Only this by the by; that the Reader may not wonder why these Dialogues found so various entertainment in Italy (for he cannot but have heard that though they have been with all veneration valued, read & applauded by the Judicious, yet they were with much detestation persecuted, suppressed & exploded by the Superstitious) I am to tell him that our Author having assigned his intimate Friends Salvatiati and Sagredo the more successfull Parts of the Challenger, and Moderator, he made the famous Commentator Simplicius to personate the Peripatetick. The Book coming out, and Pope Urban the VIII. taking his Honour to be concern'd as having in his private Capacity bin very positive in declaiming against the Samian Philosophy, and now (as he supposed) being ill delt with by Galileo who had summed up all his Arguments, and put them into the mouth of Simplicius; his Holiness thereupon conceived an implacable Displeasure against our Author, and thinking no other revenge sufficient, he employ'd his Apostolical Authority, and deals with the Confraternity to condemn him and proscribe his Book as Heretical; prostituting the Censure of the Church to his private revenge. This was Galileo's fortune in Italy: but had I not reason to hope that the English will be more hospitable, on the account of that Principle which induceth them to be civil to (I say not to dote on) Strangers, I should fear to be charged with imprudence for appearing an Interpreter to that great Philosopher. And in this confidence I shall forbear to make any large Exordium concerning him or his Book; & the rather in regard that such kind of Gauderies become not the Gravity of the Subject; as also knowing how much (coming from me) they must fall short of the Merits of it, or him but principally because I court only persons of Judgement & Candor, that can distinguish between a Native Beauty, and spurious Vernish. This only let me premise, though more to excuse my weakness in the managing, than to insinuate my ability in accomplishing this so arduous a Task, that these profound Dialogues have bin found so uneasy to Translate, that neither affectation of Novelty could induce the French, nor the Translating humour persuade the Germans to undertake them. This difficulty, as I conceived, was charged either upon the Intricacy of this manner of Writing, or upon the singular Elegance in the stile of Galileo, or else upon the

miscarriage of the unfortunate Mathias Berneggerus who first attempted to turn them into Latine for the benefit of the Learned World.

I shall not presume to Censure the Censure which the Church of Rome past upon this Doctrine and its Assertors. But on the contrary, my Author having bin indefinite in his discourse, I shall forbear to exasperate, and attempt to reconcile such persons to this Hypothesis as devout esteem for Holy Scripture, and dutifull Respect to Canonical Injunctions hath made to stand off from this Opinion: and therefore for their sakes I have at the end of the Dialogues by way of Supplement added an Epistle of Galileo to Her Most Serene Highness Christina Lotharinga the Grand Dutchesse Mother of Tuscany; as also certain Abstracts of John Kepler, Mathematician to two Emperours, and Didacus à Sunica a famous Divine of Salamanca, with an Epistle of Paulo Antonio Foscarini a learned Carmelite of Naples, that shew the Authority of Sacred Scripture in determining of Philosophical and Natural Controversies: hoping that the ingenious & impartial Reader will meet with full satisfaction in the same. And least what I have spoken of the prohibiting of these Pieces by the Inquisition may deterre any scrupulous person from reading of them, I have purposely inserted the Imprimatur by which that Office licenced them. And for a larger account of the Book or Author, I refer you to the Relation of his Life, which shall bring up the Reare in the Second Tome.

What remains of this, is that Excellent Discourse of D. Benedetto Castelli Abbate di San Benedetto Aloyfio, concerning the Mensuration of Running Waters, with other Treatises of that Learned Prelate, & of the Superintendent Corlini. Some may alledge, and I doe confess that I promised to publish the Life of Galileo in this place: But the great miscarriages of Letters from some Friends in Italy and else where, to whom I am a Debtor for several Remarques, & from whom I daily expect yet greater Helps concerning the History of that famous Personage: these disappointments, I say, joyned with the undeniable Request of some Friends, who were impatient to see Castelli in English, together with a consideration of the disproportionate Bulk that would otherwise have bin betwixt the two Volumes, perswaded me to this exchange. This deviation from my Promise I hope is Venial, and for the expiating of it I plead Supererrogation: having in each Tome made so large Additions (though to my great expence) that they make near a third part more than I stood by promise bound to Publish. That this is so will appear by comparing the Contents I here prefix with the Advertisement I formerly Printed. For not to mention those Epitomes of Kepler and à Sunica, the whole second and following Books of Castelli, were not come to my hands at the time of my penning that Paper; yet knowing how imperfect the Volume would be without them, they being partly a Supplement to the Theoremes and Problemas which the Abbot had formerly Printed, and partly experiments that had procured him and his Doctrine a very great Reputation, knowing this I saw I apprehended a necessity of publishing them with the rest: and hope that if you think I have done therein worth your acknowledgement, you will yet at least account the increase of my expence a sufficient extenuation of the Trespass: that those Additions have forced me to commit upon your Patience in point of Time.

As for the second Tome, I have only this to assure the Generous Readers; & that I am very confident I shall be much more punctual in publishing that, than (for the reasons above related,) I was able to be in setting forth this: & that they shall not be abused in advancing of their money; (as hath bin used in the like case) by selling the remaining Copies at an under rate; and & that I have a very great care that no disesteem may by my means arise unto this way of publishing Books, for that it is of excellent use in ushering Great and Costly Volumes into the World.

To say nothing of the disadvantages of Translations in general, this of mine doubtless is not without it's Errours, and overfights: but those of the Printer discounted, I hope the rest may be allowed me upon the score of Human Imbecillitie. The truth is, I have assumed the Liberty to note the Mistakes in the Florid Version of Berneggerus in the Margent, not so much to reproach him, as to convince those who told me that they accounted my pains needless, having his Latine Translation by them. The like they said of the whole two Tomes: but they thereby caused me to question their Understanding or Veracity. For some of the Books were yet never extant: As for instance; the Mechanics of Monsieur Des Cartes, a Manuscript which I found amongst the many other Rarities that enrich the well-chosen Library of my Learned and Worthy Friend Dr. Charles Scarburgh; the Experiments of Gravity, and the Life of Galileo, both my own: Others were included in Volumes of great price, or so dispersed that they were not to be purchased for any money; as those of Kepler, à Sunica, Archimedes, Tartaglia, and the Mechanics of Galileo: And the remainder, though easier to procure, were harder to be understood; as Tartaglia his notes on Archimedes, Torricellio his Doctrine of Projects, Galileo his Epistle to the Dutchesse of Tuscany, and above all his Dialogues de Motu; (never till now done into any Language) which were so intermixt of Latine and Italian, that the difficulty of the Stile, joyned with the intricatenesse of the Subject rendered them unpleasant, if not wholly Unintelligible, to such as were not absolute Masters of both the Tongues.

To conclude; according to the entertainment that you please to afford these Collections, I shall be encouraged to proceed with the Publication of a large Body of Hydrography; declaring the History, Art, Lawes, and Appendages of that Princely Study of Navigation, wherein I have omitted nothing of note that can be found either in Dudley, Fournier, Aurigarius, Nonius, Snellius, Marfennus, Baysius, Moriceus, Blondus, Wagoner, abroad, or learnt amongst our Mariners at home, touching the Office of an Admiral, Commander, Pilot, Modeller, Shipwright, Gunner, &c.

But order requiring that I should discharge my first Obligation before I contract a second; I shall detain you no longer in the Portall, but put you into possession of the Premises,

Novemb. 20. 1661.

T. S.

THE

THE
SYSTEME
OF THE
WORLD:
IN FOUR
DIALOGUES.

Wherein the Two
GRAND SYSTEMES
OF PTOLOMY and COPERNICUS
are largely discoursed of :

And the REASONS, both Philosophical and Physical,
as well on the one side as the other, impartially
and indefinitely propounded :

By GALILEUS GALILEUS LINCEUS,
A Gentleman of FLORENCE : Extraordinary Professor of
the Mathematicks in the UNIVERSITY of PISA; and
Chief Mathematician to the GRAND DUKE of TUSCANY.

Inglished from the Original Italian Copy, by THOMAS SALUSBURY.

ALCINOUS,

Δεῖ δὲ ἐλευθέριον εἶναι τῇ γνώμῃ τὸν μέλλοντα φιλοσοφᾶν.

SENECA,

Inter nullos magis quam inter PHILOSOPHOS esse debet aqua LIBERTAS.

L O N D O N,

Printed by WILLIAM LEYBOURNE. MDCLXI.

* 2

benefu

fectors.
atempt
inomial
be Dia-
nga the
Empe-
learn-
Natu-
same.
mpulous
n. And
Reare

Moyfio,
uperin-
place :
for se-
fonage:
Caltellii
rixt the
the ex-
eat ex-
ppearby
pitomes
time of
y a sup-
ut: that
y of pu-
wledge
at those

I shall
r forth
selling
eans a-
ves into

r's Er-
of Hu-
mcege-
y pains
caused
stance;
bat en-
f Gra-
ed that
Mecha-
is notes
we all
talian,
wholly

ged to
ndages
Dud-
learn
right,
you ne

THE

THE
2727
OF THE
WORLD
IN FOLD
DIALOGUES

GRAND STAIRS
OF THE
And the
as well as
and
By
A
the
Chief

published by the

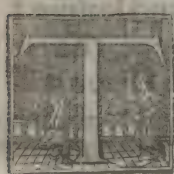
Printed by



To the most Serene Grand Duke

O F

TUSCANY.



Though the difference between Men and other living Creatures be very great, yet happily he that should say that he could shew little less between Man and Man would not speak more than he might prove. What proportion doth one bear to a thousand? and yet it is a common Proverb, *One Man is worth a thousand, when as a thousand are not worth one.* This difference hath dependence upon the different abilities of their Intellectuals; which I reduce to the being, or not being a Philosopher; in regard that Philosophy as being the proper food of such as live by it, distinguisheth a Man from the common Essence of the Vulgar in a more or less honourable degree according to the variety of that diet. In this sense he that hath the highest looks, is of highest quality; and the turning over of the great Volume of Nature, which is the proper Object of Philosophy is the way to make one look high: in which Book, although whatsoever we read, as being the Work of Almighty God, is therefore most proportionate; yet notwithstanding that is more absolute and noble wherein we more plainly deserve his art and skill. The *Constitution* of the *Universe*, among all Physical points that fall within Humane Comprehension, may, in my opinion, be preferred to the Precedency: for if that in regard of universal extent it excell all others, it ought as the Rule and Standard of the rest to goe before them in Nobility. Now if ever any persons might challenge to be signally distinguished for Intellectuals from other men;

Pro 6

Ptolomey and *Copernicus* were they that have had the honour to see farthest into, and discourse most profoundly of the *Worlds Systeme*. About the Works of which famous Men these *Dia-*lous being chiefly conversant, I conceived it my duty to Dedicate them only to *Your Highness*. For laying all the weight upon these two, whom I hold to be the Ablest Wits that have left us their Works upon these Subjects; to avoid a Solecisme in Manners, I was obliged to address them to Him, who with me, is the Greatest of all Men, from whom they can receive either Glory or Patrociny. And if these two persons have so farre illuminated my Understanding as that this my Book may in a great part be confessed to belong to them, well may it also be acknowledged to belong to *Your Highness*, unto whose Bounteous Magnificence I owe the time and leasure I had to write it, as also unto Your Powerful Assistance, (never weary of honouring me) the means that at length I have had to publish it. May *Your Highness* therefore be pleased to accept of it according to Your accustomed Goodness; and if any thing shall be found therein, that may be subservient towards the information or satisfaction of those that are Lovers of Truth; let them acknowledge it to be due to *Your Self*, who are so expert in doing good, that Your Happy Dominion cannot shew the man that is concerned in any of those general Calamities that disturb the World; so that Praying for Your Prosperity, and continuance in this Your Pious and Laudable Custom, I humbly kiss Your Hands;

Your Most Serene Highnesses

Most Humble and most devoted

Servant and Subject

GALILEO GALILEI.



THE AUTHOR'S INTRODUCTION.

Judicious Reader,



Here was published some years since in Rome a salutiferous Edict, that, for the obviating of the dangerous Scandals of the present Age, imposed a reasonable Silence upon the Pythagorean Opinion of the Mobility of the Earth. There want not such as unadvisedly affirm, that that Decree was not the production of a sober Scrutiny, but of an illinformed Passion; or one may hear some mutter that Consultors altogether ignorant of Astronomical Observations ought not to stopp the wings of Speculative Wits with rash Prohibitions. My scale cannot keep silence when I hear these unconsiderate complaints. I thought fit, as being thoroughly acquainted with that prudent Determination, to appear openly upon the Theatre of the World as a Witness of the naked Truth. I was at that time in Rome; and had not only the audiences, but applauses of the most Eminent Prelates of that Court; nor was that Decree Published without Previous Notice given me thereof. Therefore it is my resolution in the present case to give Foreign Nations to see, that this point is as well understood in Italy, and particularly in Rome, as Transalpine Diligence can imagine it to be: and collecting together all the proper Speculations that concern the Copernican Systeme, to let them know, that the notice of all preceded the Censure of the Roman Court; and that there proceed from this Climate not only Doctrines for the health of the Soul, but also ingenious Discoveries for the recreating of the Mind.

To this end I have personated the Copernican in this Discourse; proceeding upon an Hypothesis purely Mathematical; striving by all artificial wayes to represent it Superiour, not to that of the Immobility of the Earth absolutely, but according as it is mentioned by some, that retain no more, but the name of Peripateticks, and are content, without going farther, to adore Shadows, not philosophizing with requisite caution, but with the sole remembrance of four Principles, but badly understood.

We shall treat of three principall heads. First I will endeavour to shew that all Experiments that can be made upon the Earth are insufficient means to conclude it's Mobility, but are indifferently applicable to the Earth moveable or immoveable: and I hope that on this occasion we shall discover many observable passages unknown to the Ancients. Secondly we will examine the Caelestiall Phenomena that make for the Copernican Hypothesis, as if it were to prove absolutely victorious; adding by the way certain new Observations, which yet serve only for the Astronomical Facility, not for Natural Necessity. In the third place I will propose an ingenuous Fancy. I remember that I have said many years since, that the unknown Probleme of the Tide might receive some light, admitting the Earths Motion. This Position of mine passing from one to another had found charitable Fathers that adopted it for the Issue of their own Wit. Now, because no stranger may ever appear that defending himself with our armes, shall charge us with want of caution in so principal an Accident, I have thought good to lay down those probabilities that would render it credible, admitting that the Earth did move. I hope, that by these Considerations the World will come to know, that if other Nations have Navigated more than we, we have not studied less than they; or that our returning to assert the Earths Stability, and to take the contrary only for a Mathematical Capriccio, proceeds not from inadvertency of what others have thought thereof, but (had we noother inducements) from those Reasons that Piety, Religion, the Knowledge of the Divine Omnipotency, and a consciousness of the incapacity of mans Understanding dictate unto us.

With all I conceived it very proper to express these conceits by way of Dialogue, which, as not being bound up to the rigid observance of Mathematical Laws; gives place also to Digressions that are sometimes no less curious than the principal Argument.

I chanced to be several years since, at several times, in the Stupendious City of Venice, where I conversed with Signore Giovan Francesco Sagredo of a Noble Extraction, and piercing Wit. There came thither from Florence at the same time Signore Filippo Salviati, whose least glory was the Eminence of his Blood, and Magnificence of his Estate: a sublime Wit that fed not more hungerly upon any pleasure than on elevated Speculations. In the company of these two I often discoursed of these matters before a certain Peripatetic Philosopher who seemed to have no greater obstacle in understanding of the Truth, than the Fame he had acquired by Aristotelical Interpretations.

Now, seeing that inexorable Death hath deprived Venice and Florence of those two great Lights in the very Meridian of their years, I did resolve, as far as my poor ability would permit, to perpetuate their lives to their honour in these leaves, bringing them in as Interlocutors in the present Controversy. Nor shall the Honest Peripatetic want his place, to whom for his excessive affection towards the Commentaries of Simplicius, I thought fit, without mentioning his own Name, to leave that of the Author he so much respected. Let those two great Souls, ever venerable to my heart, please to accept this public Monument of my never-dying Love; and let the remembrance of their Eloquence assist me in delivering to Posterity the Considerations that I have promised.

There casually happened (as was usual) several discourses at times between these Gentlemen, the which had rather inflamed than satisfied in their wits the thirst they had to be learning; whereupon they took a discreet resolution to meet together for certain dayes, in which all other business set aside, they might betake themselves more methodically to contemplate the Wonders of God in Heaven, and in the Earth: the place appointed for their meeting being in the Palace of the Noble Sagredo, after the due, but very short complements; Signore Salviati began in this manner.



GALI-

The CONTENTS of the FIRST TOME.

PART THE FIRST.

- Treatise I.* GALILEUS GALILEUS, his SYSTEME of the WORLD: in Four DIALOGUES.
- II. HIS EPISTLE to her SERENE HIGHNESSE CHRISTIANA LOTHERINGA GRAND DUTCHESS of TUSCANY, touching the Ancient and Modern DOCTRINE of HOLY FATHERS, and JUDICIOUS DIVINES, concerning the AUTHORITY of SACRED SCRIPTURE in PHILOSOPHICAL CONTROVERSIES.
- III. JOHANNES KEPLERUS, his RECONCILING of TEXTS of SACRED SCRIPTURE that seem to oppose the DOCTRINE of the EARTH'S MOBILITY: abstracted from his INTRODUCTION unto his LEARNED COMMENTARIES upon the PLANET MARS.
- IV. DIDACUS A STUNICA, a learned SPANISH DIVINE, his RECONCILING of the said DOCTRINE with the TEXTS of SACRED SCRIPTURE; abstracted from his COMMENTARIE upon JOB.
- V. PAULUS ANTONIUS FOSEARINUS, a CARMELITE, his EPISTLE to SEBASTIANUS FANTONUS, the GENERAL of his ORDER, concerning the PYTHAGOREAN and COPERNICAN OPINION of the MOBILITY of the EARTH, and STABILITY of the SUN; and of the NEW SYSTEME of CONSTITUTION of the WORLD: in which he reconcileth the TEXTS of SACRED SCRIPTURE, and ASSERTIONS of DIVINES, commonly alledged against this OPINION.

A Table of the most observable Persons and Matters mentioned in the First Part.

PART THE SECOND.

- I. D. BENEDICTUS CASTELLUS, ABBOT of S. BENEDICTUS ALOYSIUS, his DISCOURSE of the MENSURATION OF RUNNING WATERS: The First BOOK.
- II. HIS LETTER to GALILEUS, representing the state of the Lake of PERUGIA in TUSCANY.
- III. HIS GEOMETRICAL DEMONSTRATIONS of the MEASURE of RUNNING WATERS.
- IV. HIS DISCOURSE of the MENSURATION OF RUNNING WATERS: The Second BOOK.
- V. HIS CONSIDERATIONS concerning the LAKE of VENICE. In two DISCOURSES.
- VI. HIS RULE for computing the quantity of MUD and SAND that LAND-FLOODS bring down to, and leave in the LAKE of VENICE.
- VII. HIS LETTER to Father FRANCESCO DI S. GIOVSEPPE, wherein, at the instance of PRINCE LEOPALDO, he delivereth his judgment concerning the turning FIUME MORTO (a River near PISA in TUSCANY) into the SEA, and into the River SERCHIO.
- VIII. HIS second LETTER in answer to certain OBJECTIONS proposed, and DIFFICULTIES observed by SIGNORE BARTOLOTTI, in that affair of the DIVERSION of FIUME MORTO.
- IX. HIS CONSIDERATION upon the DRAINING of the PONTINE FENNS in CALABRIA.
- X. HIS CONSIDERATION upon the DRAINING of the TERRITORIES of BOLOGNA, FERRARA, and ROMAGNA.
- XI. HIS LETTER to D. FERRANTE CESARINI, applying his DOCTRINE to the MENSURATION of the LENGTH, and DISTRIBUTION of the QUANTITY of the WATERS of RIVERS, SPRINGS, AQUEDUCTS, &c.
- XII. D. CORSINUS, SUPERINTENDENT of the GENERAL DRAINS, and PRESIDENT of ROMAGNA, his RELATION of the state of the WATERS in the TERRITORIES of BOLOGNA and FERRARA.

A Table of the most observable Persons and Matters mentioned in the Second Part.

The CONTENTS of the SECOND TOME.

PART THE FIRST.

- Treatise I.* GALILEUS GALILEUS, his MATHEMATICAL DISCOURSES and DEMONSTRATIONS touching two NEW SCIENCES, pertaining to the MECHANICKS, and LOCAL MOTION: with an APPENDIX of the CENTRE of GRAVITY of some SOLIDS in Four DIALOGUES.
- II. HIS MECHANICKS; a New PRICE.
- III. RHENATUS DES CARTES, his MECHANICKS; translated from his FRENCH MANUSCRIPT; a New PRICE.
- IV. ARCHIMEDES, his Tract DE INSIDENTIBUS HUMIDO; with the NOTES and DEMONSTRATIONS of NICOLAUS TARTALEUS, in Two BOOKS.
- V. GALILEUS his DISCOURSE of the things that move in or upon the WATER.
- VI. NICOLAUS TARTALEUS his INVENTIONS for DIVING UNDER WATER, RAISING OF SHIPS SUNK, &c. in TWO BOOKS.

PART THE SECOND.

- I. EVANGELISTA TORRICELLIUS, his DOCTRINE OF PROJECTS, and TABLES of the RANGES of GREAT GUNNS of all sorts; wherein he detects sundry ERRORS in GUNNERY: AN EPITOME.
- II. T. S. his EXPERIMENTS of the COMPARATIVE GRAVITY OF BODIES in the AIRE and WATER.
- III. GALILEUS GALILEUS, his LIFE: in Five BOOKS,
- BOOK I. Containing Five Chapters.
- Chap. 1.* His Country.
2. His Parents and Extraction.
3. His time of Birth.
4. His first Education.
5. His Masters.
- II. Containing Three Chapters.
- Chap. 1.* His judgment in several Learnings.
2. His Opinions and Doctrine.
3. His Auditors and Scholars.
- III. Containing Four Chapters.
- Chap. 1.* His behaviour in Civil Affairs.
2. His manner of Living.
3. His morall Virtues.
4. His misfortunes and troubles.
- IV. Containing Four Chapters.
- Chap. 1.* His person described.
2. His Will and Death.
3. His Inventions.
4. His Writings.
5. His Dialogues of the Systeme in particular, containing Nine Sections.
- Section 1. Of Astronomy in General; its Definition, Praise, Original.
2. Of Astronomers: a Chronological Catalogue of the most famous of them.
3. Of the Doctrine of the Earths Mobility, &c. its Antiquity, and Progresse from Pythagoras to the time of Copernicus.
4. Of the Followers of Copernicus, unto the time of Galileus.
5. Of the severall Systemes amongst Astronomers.
6. Of the Allegations against the Copern. Systeme, in 77 Arguments taken out of Ricciolo, with Answers to them.
7. Of the Allegations for the Copern. Systeme in 50 Arguments.
8. Of the Scriptures Authorities produced against and for the Earths mobility.
9. The Conclusion of the whole Chapter.
- V. Containing Four Chapters.
- Chap. 1.* His Patrons, Friends, and Emulators.
2. Authors judgments of him.
3. Authors that have writ for, or against him.
4. A Conclusion in certain Reflections upon his whole Life.
- A Table of the whole Second TOME.

The

ND
s and DEMON
to the MECHA
the CENTRE of
om his FRENCH
the NOTES and
wo BOOKS.
ic WATER.
NDER WATER,
ts, and TABLES
ie detects sundry
BODIES in the

GALILÆUS

Galilæus Lyncæus,

HIS

SYSTEME

OF THE

WORLD.

The First Dialogue.

INTERLOCUTORS.

SALVIATUS, SAGREDUS, and SIMPLICIUS.

SALVIATUS.



It was our yesterdaies resolution, and agreement, that we should to day discourse the most distinctly, and particularly we could possible, of the natural reasons, and their efficacy that have been hitherto alledged on the one or other part; by the maintainers of the Positions, *Aristotelian*, and *Ptolomaique*; and by the followers of the *Copernican Systeme*: And because

Copernicus placing the Earth among the moveable Bodies of Heaven, comes to constitute a Globe for the same like to a Planet; it would be good that we began our disputation with the examination of what, and how great the energy of the *Peripateticks* arguments is, when they demonstrate, that this *Hypothesis* is impos-

*Copernicus repa-
reth the Earth a
Globe like to a Pla-
net.*

A

fibre

Cœlestial substances that are inalterable, and Elementary that be alterable, are necessary in the opinion of Aristotle.

sible : Since that it is necessary to introduce in Nature, substances different betwixt themselves, that is, the Cœlestial, and Elementary ; that impassible and immortal, this alterable and corruptible. Which argument *Aristotle* handleth in his book *De Cœlo*, insinuating it first, by some discourses dependent on certain general assumptions, and afterwards confirming it with experiments and particular demonstrations : following the same method, I will propound, and freely speak my judgement, submitting my self to your censure, and particularly to *Simplicius*, a Stout Champion and contender for the *Aristotelian* Doctrine.

Aristotle maketh the World perfect, because it hath the threefold demonstration.

And the first Step of the *Peripatetick* arguments is that, where *Aristotle* proveth the integrity and perfection of the World, telling us, that it is not a simple line, nor a bare superficies, but a body adorned with Longitude, Latitude, and Profundity ; and because there are no more dimensions but these three ; The World having them, hath all, and having all, is to be concluded perfect. And again, that by simple length, that magnitude is constituted, which is called a Line, to which adding breadth, there is framed the Superficies, and yet further adding the altitude or profundity, there results the Body, and after these three dimensions there is no passing farther, so that in these three the integrity, and to so speak, totality is terminated, which I might but with justice have required *Aristotle* to have proved to me by necessary consequences, the rather in regard he was able to do it very plainly, and speedily.

Aristotles demonstrations to prove the dimensions to be three and no more.

The number three celebrated amongst the Pythagorians

Omne, Totum & Perfectum.

Or Solid.

SIMPL. What say you to the excellent demonstrations in the 2. 3. and 4. Texts, after the definition of *Continual* ? have you it not first there proved, that there is no more but three dimensions, for that those three are all things, and that they are every where ? And is not this confirmed by the Doctrine and Authority of the *Pythagorians*, who say that all things are determined by three, beginning, middle, and end, which is the number of All ? And where leave you that reason, namely, that as it were by the law of Nature, this number is used in the sacrifices of the Gods ? And why being so dictated by nature, do we attribute to those things that are three, and not to lesse, the title of all ? why of two is it said both, and not all, unless they be three ? And all this Doctrine you have in the second Text. Afterwards in the third, *Ad pleniorē sciētiā*, we read that *All*, the *Whole*, and *Perfect*, are formally one and the same ; and that therefore onely the *Body*, amongst magnitudes is perfect : because it is determined by three, which is All, and being divisible three manner of waies, it is every way divisible ; but of the others, some are dividible in one manner, and some in two, because according to the number affixed, they have their division and continuity, and thus one magnitude is continue one way, another two, a third, namely the *Body*, every way. More.

DIALOGUE. I.

3

Moreover in the fourth Text ; doth he not after some other Doctrines, prove it by another demonstration ? *Scilicet*, That no transition is made but according to some defect (and so there is a transition or passing from the line to the superficies, because the line is defective in breadth) and that it is impossible for the perfect to want any thing, it being every way so; therefore there is no transition from the Solid or Body to any other magnitude. Now think you not that by all these places he hath sufficiently proved, how that there's no going beyond the three dimensions ; Length, Breadth, and Thickness, and that therefore the body or solid, which hath them all, is perfect ?

SALV. To tell you true, I think not my self bound by all these reasons to grant any more but onely this, That that which hath beginning, middle, and end, may, and ought to be called perfect: But that then, because beginning, middle, and end, are Three, the number Three is a perfect number, and hath a faculty of conferring *Perfection* on those things that have the same, I find no inducement to grant ; neither do I understand, nor believe that, for example, of feet, the number three is more perfect then four or two, nor do I conceive the number four to be any imperfection to the Elements : and that they would be more perfect if they were three. Better therefore it had been to have left these subtleties to the Rhetoricians, and to have proved his intent, by necessary demonstration ; for so it behoves to do in demonstrative sciences.

SIMPL. You seem to scorn these reasons, and yet it is all the Doctrine of the *Pythagorians*, who attribute so much to numbers ; and you that be a *Mathematician*, and believe many opinions in the *Pythagorick* Philosophy, seem now to contemn their Mysteries.

SALV. That the *Pythagorians* had the science of numbers in high esteem, and that *Plato* himself admired humane understanding, and thought that it pertook of Divinity, for that it understood the nature of numbers, I know very well, nor should I be far from being of the same opinion : But that the Mysteries for which *Pythagoras* and his sect, had the Science of numbers in such veneration, are the follies that abound in the mouths and writings of the vulgar, I no waies credit: but rather because I know that they, to the end admirable things might not be exposed to the contempt, and scorne of the vulgar, censured as sacrilegious, the publishing of the abstruse properties of Numbers, and incommensurable and irrational quantities, by them investigated ; and divulged, that he who discovered them, was tormented in the other World : I believe that some one of them to deter the common sort, and free himself from their inquisitiveness, told them that the mysteries of numbers were those trifles, which afterwards did so

A 2

spread

Plato held that humane understanding partook of divinity, because it understood numbers.

The Mystery of Pythagorick numbers fabulous.

De Papyrio p. 2. textato, Gellius 1. 2. 3.

spread amongst the vulgar; and this with a discretion and subtlety resembling that of the prudent young man, that to be freed from the importunity of his inquisitive Mother or Wife, I know not whether, who pressed him to impart the secrets of the Senate, contrived that story, which afterwards brought her and many other women to be derided and laught at by the same Senate.

SIMPL. I will not be of the number of those who are over curious about the *Pythagorick* mysteries; but adhering to the point in hand; I reply, that the reasons produced by *Aristotle* to prove the dimensions to be no more than three, seem to me conclusive, and I believe, That had there been any more evident demonstrations thereof, *Aristotle* would not have omitted them.

SAGR. Put in at least, if he had known, or remembered any more. But you *Salviatus* would do me a great pleasure to alledge unto me some arguments that may be evident, and clear enough for me to comprehend.

SALV. I will; and they shall be such as are not onely to be apprehended by you, but even by *Simplicius* himself: nor onely to be comprehended; but are also already known, although happily unobserved; and for the more easie understanding thereof, we will take this Pen and Ink, which I see already prepared for such occasions, and describe a few figures. And first we will note [Fig. 1. at the end of this Dialog.] these two points AB, and draw from the one to the other the curved lines, ACB, and ADB, and the right line AB, I demand of you which of them, in your mind, is that which determines the distance between the terms AB, & why?

SAGR. I should say the right line, and not the crooked, as well because the right is shorter, as because it is one, sole, and determinate, whereas the others are infinit, unequal, and longer; and my determination is grounded upon that, That it is one, and certain.

SALV. We have then the right line to determine the length between the two terms; let us add another right line and parallel to AB, which let be CD, [Fig. 2.] so that there is put between them a superficies, of which I desire you to assign me the breadth; therefore departing from the point A, tell me how, and which way you will go, to end in the line CD, and so to point me out the breadth comprehended between those lines; let me know whether you will terminate it according to the quantity of the curved line AE, or the right line AF, or any other.

SIMPL. According to the right AF, and not according to the crooked, that being already excluded from such an use.

SAGR. But I would take neither of them, seeing the right line AF runs obliquely; But would draw a line, perpendicular to CD, for this should seem to me the shortest, and the properest of infinite that are greater, and unequal to one another, which may be
pro-

A Geometrical demonstration of the triple dimension.

DIALOGUE I.

5

produced from the term A to any other part of the opposite line C D.

SALV. Your choice, and the reason you bring for it in my judgment is most excellent; so that by this time we have proved that the first dimension is determined by a right line, the second namely the breadth with another line right also, and not onely right, but withall, at right-angles to the other that determineth the length, and thus we have the two dimensions of length and breadth, definite and certain. But were you to bound or terminate a height, as for example, how high this Roof is from the pavement, that we tread on, being that from any point in the Roof, we may draw infinite lines, both curved, and right, and all of diverse lengths to infinite points of the pavement, which of all these lines would you make use of?

SAGR. I would fasten a line to the Seeling, and with a plummet that should hang at it, would let it freely distend it self till it should reach well near to the pavement, and the length of such a thread being the straightest and shortest of all the lines, that could possibly be drawn from the same point to the pavement, I would say was the true height of this Room.

SALV. Very well, And when from the point noted in the pavement by this pendent thread (taking the pavement to be levell and not declining) you should produce two other right lines; one for the length, and the other for the breadth of the superficies of the said pavement, what angles should they make with the said thread?

SAGR. They would doubtless meet at right angles, the said lines falling perpendicular, and the pavement being very plain and levell.

SALV. Therefore if you assign any point, for the term from whence to begin your measure; and from thence do draw a right line, as the terminator of the first measure, namely of the length, it will follow of necessity, that that which is to design out the largeness or breadth, toucheth the first at right-angles, and that that which is to denote the altitude, which is the third dimension, going from the same point formeth also with the other two, not oblique but right angles, and thus by the three perpendiculars, as by three lines, one, certain, and as short as is possible, you have the three dimensions A B length; A C breadth, and A D height; and because, clear it is, that there cannot concur any more lines in the said point, so as to make therewith right-angles; and the dimensions ought to be determined by the sole right lines, which make between themselves right-angles; therefore the dimensions are no more, but three, and that which hath three hath all, and that which hath all, is divisible on all sides, and that which is so, is perfect, &c.

SIMP.

SIMPL. And who saith that I cannot draw other lines? why may not I protract another line underneath, unto the point A, that may be perpendicular to the rest?

SALV. You can doubtless, at one and the same point, make no more than three right lines concur, that constitute right angles between themselves.

SAGR. I see what *Simplicius* means, namely, that should the said D A be prolonged downward, then by that means there might be drawn two others, but they would be the same with the first three, differing onely in this, that whereas now they onely touch, then they would intersect, but not produce new dimensions.

In physical proofs geometrical exactness is not necessary.

SIMPL. I will not say that this your argument may not be concludent; but yet this I say with *Aristotle*, that in things natural it is not alwaies necessary, to bring *Mathematical* demonstrations.

SAGR. Grant that it were so where such proofs cannot be had, yet if this case admit of them, why do not you use them? But it would be good we spent no more words on this particular; for I think that *Salviatus* will yield, both to *Aristotle*, and you, without farther demonstration, that the World is a body, and perfect, yea most perfect, as being the greatest work of God.

Parts of the world are two, according to Aristotle, Celestial and Elementary contrary to one another.

SALV. So really it is, therefore leaving the general contemplation of the whole, let us descend to the consideration of its parts, which *Aristotle*, in his first division, makes two, and they very different and almost contrary to one another; namely the *Cœlestial*, and *Elementary*: that ingenerable, incorruptible, unalterable, unpassible, &c. and this exposed to a continual alteration, mutation, &c. Which difference, as from its original principle, he derives from the diversity of local motions, and in this method he proceeds.

Local motion of three kinds, right, circular, & mixt.

Circular, and streight motions are simple, as proceeding by simple lines.

Ad medium, à medio, & circa medium.

Leaving the sensible, if I may so speak, and retiring into the Ideal world, he begins Architectonically to consider that nature being the principle of motion, it followeth that natural bodies be indued with local motion. Next he declares local motion to be of three kinds, namely, circular, right, and mixt of right and circular: and the two first he calleth simple, for that of all lines the circular, and right are onely simple; and here somewhat restraining himself, he defineth anew, of simple motions, one to be circular, namely that which is made about the *medium*, and the other namely the right, upwards, and downwards; upwards, that which moveth from the *medium*, downwards, that which goeth towards the *medium*. And from hence he infers, as he may by and necessary consequence, that all simple motions are confined to these three kinds, namely, to the *medium*, from the *medium*, and about the *medium*; the which corresponds saith he, with what hath been said before of a body, that it also is perfected by three things, and so

is

DIALOGUE. I.

7

is its motion. Having confirmed these motions, he proceeds saying, that of natural bodies some being simple, and some composed of them (and he calleth simple bodies those, that have a principle of motion from nature, as the Fire and Earth) it follows that simple motions belong to simple bodies, and mixt to the compound; yet in such sort, that the compounded incline to the part predominant in the composition.

SAGR. Pray you hold a little *Salvatus*, for I find so many doubts to spring up on all sides in this discourse, that I shall be constrained, either to communicate them if I would attentively hearken to what you shall add, or to take off my attention from the things spoken, if I would remember objections.

SALV. I will very willingly stay, for that I also run the same hazard, and am ready at every step to lose my self whilst I sail between Rocks, and boisterous Waves, that make me, as they say, to lose my *Compass*; therefore before I make them more, propound your difficulties.

SAGR. You and *Aristotle* should at first take me a little out of the sensible World, to tell me of the *Architecture*, wherewith it ought to be fabricated; and very appositly begin to tell me, that a natural body is by nature moveable, nature being (as elsewhere it is defined) the principle of motion. But here I am somewhat doubtfull why *Aristotle* said not that of natural bodies, some are moveable by nature, and others immoveable, for that in the definition, nature is said to be the principle of Motion, and Rest; for if natural bodies have all a principle of motion, either he might have omitted the mention of Rest, in the definition of nature: or not have introduced such a definition in this place. Next, as to the declaration of what *Aristotle* intends by simple motions, and how by Spaces he determines them, calling those simple, that are made by simple lines, which are onely the right, and circular, I entertain it willingly; nor do I desire to tenter the instance of the Helix, about the Cylinder; which in that it is in every part like to it self, might seemingly be numbred among simple lines. But herein I cannot concur, that he should so restrain simple motions (whilst he seems to go about to repeat the same definition in other words) as to call one of them the motion about the *medium*, the others *Sursum* & *Deorsum*, namely upwards and downward; which terms are not to be used, out of the World fabricated, but imply it not onely made, but already inhabited by us; for if the right motion be simple, by the simplicity of the right line, and if the simple motion be natural, it is made on every side, to wit, upwards, downwards, backwards, forwards, to the right, to the left, and if any other way can be imagined, provided it be straight, it shall agree to any simple natural body; or

The definition of Nature, either immoveable, or unscissible, produced by Aristotle.

The Helix about the Cylinder may be said to be a simple line.

Aristotle accommodates the rules of Architecture to the frame of the World, and not the frame to the rules.

if not so, then the supposition of *Aristotle* is defective. It appears moreover that *Aristotle* hinteth but one circular motion alone to be in the World, and consequently but one onely Center, to which alone the motions of upwards and downwards, refer. All which are apparent proofs, that *Aristotles* aim is, to make white black, and to accommodate *Architecure* to the building, and not to modle the building according to the precepts of *Architecure*: for if I should say that Nature in Universal may have a thousand Circular Motions, and by consequence a thousand Centers, there would be also a thousand motions upwards, and downwards. Again he makes as hath been said, a simple motion, and a mixt motion, calling simple, the circular and right; and mixt, the compound of them two: of natural bodies he calls some simple (namely those that have a natural principle to simple motion) and others compound: and simple motions he attributes to simple bodies, and the compounded to the compound; but by compound motion he doth no longer understand the mixt of right and circular, which may be in the World; but introduceth a mixt motion as impossible, as it is impossible to mixe opposite motions made in the same right line, so as to produce from them a motion partly upwards, partly downwards; and, to moderate such an absurdity, and impossibility, he asserts that such mixt bodies move according to the simple part predominant: which necessitates others to say, that even the motion made by the same right line is sometimes simple, and sometimes also compound: so that the simplicity of the motion, is no longer dependent onely on the simplicity of the line.

Right motion, sometimes simple, and sometimes mixt according to Arist.

SIMPL. How? Is it not difference sufficient, that the simple and absolute are more swift than that which proceeds from predomination? and how much faster doth a piece of pure Earth descend, than a piece of Wood?

SAGR. Well, *Simplicius*; But put case the simplicity for this cause was changed, besides that there would be a hundred thousand mixt motions, you would not be able to determine the simple; nay farther, if the greater or lesse velocity be able to alter the simplicity of the motion, no simple body should move with a simple motion; since that in all natural right motions, the velocity is ever encreasing, and by consequence still changing the simplicity, which as it is simplicity, ought of consequence to be immutable, and that which more importeth, you charge *Aristotle* with another thing, that in the definition of motions compounded, he hath not made mention of tardity nor velocity, which you now insert for a necessary and essential point. Again you can draw no advantage from this rule, for that there will be amongst the mixt bodies some, (and that not a few) that will move swiftly, and

DIALOGUE I.

9

and others more slowly than the simple; as for example, Lead, and Wood, in comparison of earth; and therefore amongst these motions, which call you the simple, and which the mixt?

SIMPL. I would call that simple motion, which is made by a simple body, and mixt, that of a compound body.

SAGR. Very well, and yet *Simplicius* a little before you said, that the simple, and compound motions, discovered which were mixt, and which were simple bodies; now you will have me by simple and mixt bodies, come to know which is the simple, and which is the compound motion: an excellent way to keep us ignorant, both of motions and bodies. Moreover, you have also a little above declared, how that a greater velocity did not suffice; but you seek a third condition for the definement of simple motion, for which *Aristotle* contented himself with one alone, namely, of the simplicity of the Space, or *Medium*: But now according to you, the simple motion, shall be that which is made upon a simple line, with a certain determinate velocity, by a body simply moveable. Now be it as you please, and let us return to *Aristotle*, who defineth the mixt motion to be that compounded of the right, and circular, but produceth not any body, which naturally moveth with such a motion.

SALV. I come again to *Aristotle*, who having very well, and Methodically begun his discourse; but having a greater aim to rest at, and hit a mark, predefigned in his minde; then that to which his method lead him, digressing from the purpose, he comes to assert, as a thing known and manifest, that as to the motions directly upwards or downwards, they naturally agree to Fire, and Earth; and that therefore it is necessary, that besides these bodies, which are neer unto us, there must be in nature another, to which the circular motion may agree: which shall be so much the more excellent by how much the circular motion is more perfect, then the streight, but how much more perfect that is than this, he determines from the greatness of the circular lines perfection above the right line; calling that perfect, and this imperfect; imperfect, because if infinite it wanteth a termination, and end: and if it be finite, there is yet something beyond which it may be prolonged. This is the basis, ground work, and master-stone of all the Fabrick of the *Aristotelian* World, upon which they superstruct all their other properties, of neither heavy nor light, of ingenerable incorruptible, exemption from all motions, some onely the local, &c. And all these passions he affirmeth to be proper to a simple body that is moved circularly; and the contrary qualities of gravity, levity, corruptibility, &c. he assigns to bodies naturally moveable in a streight line, for that if we have already discovered defects in the foundation, we may rationally question what soever may farther

The circular line perfect, according to Aristotle, and but the right imperfect, and why.

ther built thereon. I deny not, that this which *Aristotle* hitherto hath introduced, with a general discourse dependent upon universal primary principles, hath been since in process of time, re-inforced with particular reasons, and experiments; all which it would be necessary distinctly to consider and weigh; but because what hath been said hitherto presents to such as consider the same many and no small difficulties, (and yet it would be necessary, that the primary principles and fundamentals, were certain, firm, and established, that so they might with more confidence be built upon) it would not be amiss, before we farther multiply doubts, to see if haply (as I conjecture) betaking our selves to other waies, we may not light upon a more direct and secure method; and with better considered principles of Architecture lay our primary fundamentals. Therefore suspending for the present the method of *Aristotle*, (which we will re-assume again in its proper place, and particularly examine;) I say, that in the things hitherto affirmed by him, I agree with him, and admit that the World is a body enjoying all dimensions, and therefore most perfect; and I add, that as such, it is necessarily most ordinate, that is, having parts between themselves, with exquisite and most perfect order disposed; which assumption I think is not to be denied, neither by you or any other.

The world is supposed by the Author to be perfectly ordinate.

SIMPL. Who can deny it? the first particular (of the worlds dimensions) is taken from *Aristotle* himself, and its denomination of ordinate seems onely to be assumed from the order which it most exactly keeps.

Streight motion impossible in the world exactly ordinate.

SALV. This principle then established, one may immediately conclude, that if the entire parts of the World should be by their nature moveable, it is impossible that their motions should be right, or other than circular; and the reason is sufficiently easie, and manifest; for that whatsoever moveth with a right motion, changeth place; and continuing to move, doth by degrees more and more remove from the term from whence it departed, and from all the places thorow which it successively passed; and if such motion naturally suited with it, then it was not at the beginning in its proper place; and so the parts of the World were not disposed with perfect order. But we suppose them to be perfectly ordinate, therefore as such, it is impossible that they should by nature change place, and consequently move in a right motion. Again, the right motion being by nature infinite, for that the right line is infinite and indeterminate, it is impossible that any moveable can have a natural principle of moving in a right line; namely toward the place whither it is impossible to arrive, there being no præ-finite term; and nature, as *Aristotle* himself saith well, never attempts to do that which can never be done,

Right motion by nature infinite. Motion by a right line naturally impossible. Nature attempts not things impossible to be effected.

nor

nor essays to move whither it is impossible to arrive. And if any one should yet object, that albeit the right line; and consequently the motion by it is producible *in infinitum*, that is to say, is interminate; yet nevertheless Nature; as one may say, arbitrarily hath assigned them some terms; and given natural instincts to its natural bodies to move unto the same; I will reply, that this might perhaps be fabled to have come to pass in the first Chaos, where indistinct matters confusedly and inordinately wandered; to regulate which, Nature very appositely made use of right motions, by which, like as the well-constituted, moving, disorder themselves, so were they which were before depravedly disposed by this motion ranged in order: but after their exquisite distribution and collocation, it is impossible that there should remain natural inclinations in them of longer moving in a right motion; from which now would ensue their removal from their proper and natural place, that is to say, their disordination; we may therefore say that the right motion serves to conduct the matter to erect the work; but once erected, that it is to rest immoveable, or if moveable, to move ~~in a~~ only circularly. Unless we will say with *Plato*, that these mundane bodies, after they had been made and finished, were for a certain time moved by their Maker, in a right motion, but that after their attainment to certain and determinate places, they were revolved one by one in Spheres, passing from the right to the circular motion, wherein they have been ever since kept and maintained. A sublime concept; and worthy indeed of *Plato*: upon which, I remember to have heard our common friend the *Lyncean Academick* discourse in this manner, if I have not forgot it. Every body for any reason constituted in a state of rest, but which is by nature moveable, being set at liberty doth move; provided withal, that it have an inclination to some particular place; for should it stand indifferently affected to all, it would remain in its rest, not having greater inducement to move one way than another. From the having of this inclination necessarily proceeds, that it in its moving shall continually increase its acceleration; and beginning with a most slow motion, it shall not acquire any degree of velocity; before it shall have passed thorow all the degrees of less velocity, or greater tardity: for passing from the state of quiet (which is the infinite degree of tardity of motion) there is no reason by which it should enter into such a determinate degree of velocity, before it shall have entered into a less, and into yet a less, before it entered into that: but rather it stands with reason, to pass first by those degrees nearest to that from which it departed, and from those to the more remote; but the degree from whence the moveable began to move, is that of extreme tardity, namely of rest.

Right motion might perhaps be in the first Chaos.

Right motion is commodious to range in order, things out of order.

Mundane bodies moved in the beginning in a right line, and afterwards circularly, according to Plato.

* Thus doth he covertly and modestly stile himself throughout this work.

A moveable being in a state of rest, shall not move unless it have an inclination to some particular place.

The moveable accelerates its motion, going towards the place whither it hath an inclination.

The moveable passing from rest, passeth thorow all the degrees of tardity.

Rest the infinite degree of tardity.

The moveable doth not accelerate, save only as it approacheth nearer to its term.

Nature, to introduce in the moveable a certain degree of velocity, made it move in a right line.

Uniform velocity convenient to the circular motion.

Between rest, and any assigned degree of velocity, infinite degrees of less velocity interpose.

Nature doth not immediately confer a determinate degree of velocity, howbeit she could.

Now this acceleration of motion is never made, but when the moveable in moving acquireth it; nor is its acquit other than an approaching to the place desired, to wit, whither its natural inclination attracts it, and thither it tendeth by the shortest way; namely, by a right line. We may upon good grounds therefore say, That Nature, to confer upon a moveable first constituted in rest a determinate velocity, useth to make it move according to a certain time and space with a right motion. This presupposed, let us imagine God to have created the Orb *v. g.* of *Jupiter*, on which he had determined to confer such a certain velocity, which it ought afterwards to retain perpetually uniform; we may with *Plato* say, that he gave it at the beginning a right and accelerate motion, and that it afterwards being arrived to that intended degree of velocity, he converted its right, into a circular motion, the velocity of which came afterwards naturally to be uniform.

SAGR. I hearken to this Discourse with great delight; and I believe the content I take therein will be greater, when you have satisfied me in a doubt: that is, (which I do not very well comprehend) how it of necessity ensues, that a moveable departing from its rest, and entering into a motion to which it had a natural inclination, it passeth thorow all the precedent degrees of tardity, comprehended between any assigned degree of velocity, and the state of rest, which degrees are infinite? so that Nature was not able to confer them upon the body of *Jupiter*, his circular motion being instantly created with such and such velocity.

SALV. I neither did, nor dare say, that it was impossible for God or Nature to confer that velocity which you speak of, immediately; but this I say, that *de facto* she did not do it; so that the doing it would be a work extra-natural, and by consequence miraculous.

SAGR. Then you believe, that a stone leaving its rest, and entering into its natural motion towards the centre of the Earth, passeth thorow all the degrees of tardity inferior to any degree of velocity?

SALV. I do believe it, nay am certain of it; and so certain, that I am able to make you also very well satisfied with the truth thereof.

SAGR. Though by all this daies discourse I should gain no more but such a knowledge, I should think my time very well bestowed.

SALV. By what I collect from our discourse, a great part of your scruple lieth in that it should in a time, and that very short, pass thorow those infinite degrees of tardity precedent to any velocity, acquired by the moveable in that time: and therefore before we go any farther, I will seek to remove this difficulty, which shall

shall be an easie task; for I reply, that the moveable passeth by the aforesaid degrees, but the passage is made without staying in any of them; so that the passage requiring but one sole instant of time, and every small time containing infinite instants, we shall not want enough of them to assign its own to each of the infinite degrees of tardity; although the time were never so short.

The moveable departing from rest passeth thorow all degrees of velocity without staying in any.

SAGR. Hitherto I apprehend you; nevertheless it is very much that that Ball shot from a Cannon (for such I conceive the cadent moveable) which yet we see to fall with such a precipice, that in less than ten pulses it will pass two hundred yards of altitude; should in its motion be found conjoynd with so small a degree of velocity, that, should it have continued to have moved at that rate without farther acceleration, it would not have past the same in a day.

SALV. You may say, nor yet in a year, nor in ten, no nor in a thousand; as I will endeavour to shew you, and also happily without your contradiction, to some sufficiently simple questions that I will propound to you. ~~Therefore tell me if you make any question of granting that~~ that that ball in descending goeth increasing its *impetus* and velocity.

SAGR. I am most certain it doth.

SALV. And if I should say that the *impetus* acquired in any place of its motion, is so much, that it would suffice to re-carry it to that place from which it came, would you grant it?

SAGR. I should consent to it without contradiction, provided alwaies, that it might imploy without impediment its whole *impetus* in that sole work of re-conducting it self, or another equal to it, to that self-same height as it would do, in case the Earth were bored thorow the centre, and the Bullet fell a thousand yards from the said centre, for I verily believe it would pass beyond the centre, ascending as much as it had descended; and this I see plainly in the experiment of a plummet hanging at a line, which removed from the perpendicular, which is its state of rest, and afterwards let go, falleth towards the said perpendicular, and goes as far beyond it; or onely so much less, as the opposition of the air, and line, or other accidents have hindred it. The like I see in the water, which descending thorow a pipe, re-mounts as much as it had descended.

The ponderous mover descending acquires impetus sufficient to re-carry it to the like height.

SALV. You argue very well. And for that I know you will not scruple to grant that the acquist of the *impetus* is by means of the receding from the term whence the moveable departed, and its approach to the centre, whither its motion tendeth; will you stick to yeeld, that two equal moveables, though descending by divers lines, without any impediment, acquire equal *impetus*, provided that the approaches to the centre be equal?

SAGR.

G. GALILEUS, his Systeme.

SAGR. I do not very well understand the question.

SALV. I will express it better by drawing a Figure : therefore I will suppose the line AB [in Fig. 3.] parallel to the Horizon, and upon the point B, I will erect a perpendicular BC ; and after that I adde this slant line CA. Understanding now the line CA to be an inclining plain exquisitely polished, and hard, upon which descendeth a ball perfectly round and of very hard matter, and such another I suppose freely to descend by the perpendicular CB : will you now confesse that the *impetus* of that which descends by the plain CA, being arrived to the point A, may be equal to the *impetus* acquired by the other in the point B, after the descent by the perpendicular CB ?

The impetuosity of moveables equally approaching to the centre, are equal.

SAGR. I resolutely believe so : for in effect they have both the same proximity to the centre, and by that, which I have already granted, their impetuosities would be equally sufficient to re-carry them to the same height.

SALV. Tell me now what you believe the same ball would do put upon the Horizontal plane AB ?

Upon an horizontal plane the moveable lieth still.

SAGR. It would lie still, the said plane having no declination.

SALV. But on the inclining plane CA it would descend, but with a gentler motion than by the perpendicular CB ?

SAGR. I may confidently answer in the affirmative, it seeming to me necessary that the motion by the perpendicular CB should be more swift, than by the inclining plane CA ; yet nevertheless, if this be, how can the Cadent by the inclination arrived to the point A, have as much *impetus*, that is, the same degree of velocity, that the Cadent by the perpendicular shall have in the point B ? these two Propositions seem contradictory.

The velocity by the inclining plane equal to the velocity by the perpendicular, and the motion by the perpendicular swifter than by the inclination.

SALV. Then you would think it much more false, should I say, that the velocity of the Cadents by the perpendicular, and inclination, are absolutely equal : and yet this is a Proposition most true, as is also this that the Cadent moveth more swiftly by the perpendicular, than by the inclination.

SAGR. These Propositions to my ears sound very harsh : and I believe to yours *Simplicius* ?

SIMPL. I have the same sense of them.

SALV. I conceit you jest with me, pretending not to comprehend what you know better than my self : therefore tell me *Simplicius*, when you imagine a moveable more swift than another, what conceit do you fancy in your mind ?

SIMPL. I fancie one to pass in the same time a greater space than the other, or to move equal spaces, but in lesser time.

SALV. Very well : and for moveables equally swift, what's your conceit of them ?

SIMPL. I fancie that they pass equal spaces in equal times.

SALV.

SALV. And have you no other conceit thereof than this?

SIMPL. This I think to be the proper definition of equal motions.

SAGR. We will add moreover this other : and call that equal velocity, when the spaces passed have the same proportion, as the times wherein they are past, and it is a more universal definition.

Velocities are said to be equal, when the spaces passed are proportionate to their time.

SALV. It is so : for it comprehendeth the equal spaces past in equal times, and also the unequal past in times unequal, but proportionate to those spaces. Take now the same Figure, and applying the concept that you had of the more hastie motion, tell me why you think the velocity of the Cadent by CB, is greater than the velocity of the Descendent by CA?

SIMPL. I think so ; because in the same time that the Cadent shall pass all CB, the Descendent shall pass in CA, a part less than CB.

SALV. True ; and thus it is proved, that the moveable moves more swiftly by the perpendicular, than by the inclination. Now consider, if in this same Figure one may any way evince the other concept, and ~~show~~ that the moveables were equally swift by both the lines CA and CB.

SIMPL. I see no such thing ; nay rather it seems to contradict what was said before.

SALV. And what say you, *Sagredus* ? I would not teach you what you knew before, and that of which but just now you produced me the definition.

SAGR. The definition I gave you, was, that moveables may be called equally swift, when the spaces passed are proportional to the times in which they passed ; therefore to apply the definition to the present case, it will be requisite, that the time of descent by CA, to the time of falling by CB, should have the same proportion that the line CA hath to the line CB ; but I understand not how that can be, for that the motion by CB is swifter than by CA.

SALV. And yet you must of necessity know it. Tell me a little, do not these motions go continually accelerating?

SAGR. They do ; but more in the perpendicular than in the inclination.

SALV. But this acceleration in the perpendicular, is it yet notwithstanding such in comparison of that of the inclined, that two equal parts being taken in any place of the said perpendicular and inclining lines, the motion in the parts of the perpendicular is alwaies more swift, than in the part of the inclination?

SAGR. I say not so : but I could take a space in the inclination, in which the velocity shall be far greater than in the like space taken in the perpendicular ; and this shall be, if the space in the perpendicular

perpendicular should be taken near to the end C, and in the inclination, far from it.

SALV. You see then, that the Proposition which saith, that the motion by the perpendicular is more swift than by the inclination, holds not true universally, but onely of the motions, which begin from the extremity, namely from the point of rest: without which restriction, the Proposition would be so deficient, that its very direct contrary might be true; namely, that the motion in the inclining plane is swifter than in the perpendicular: for it is certain, that in the said inclination, we may take a space past by the moveable in less time, than the like space past in the perpendicular. Now because the motion in the inclination is in some places more, in some less, than in the perpendicular; therefore in some places of the inclination, the time of motion of the moveable, shall have a greater proportion to the time of the motion of the moveable, by some places of the perpendicular, than the space passed, to the space passed: and in other places, the proportion of the time to the time, shall be less than that of the space to the space. As for example: two moveables departing from their quiescence, namely, from the point C, one by the perpendicular C B, [in Fig. 4.] and the other by the inclination C A, in the time that, in the perpendicular, the moveable shall have past all C B, the other shall have past C T lesser. And therefore the time by C T, to the time by C B (which is equal) shall have a greater proportion than the line C T to C B, being that the same to the less, hath a greater proportion than to the greater. And on the contrary, if in C A, prolonged as much as is requisite, one should take a part equal to C B, but past in a shorter time; the time in the inclination shall have a less proportion to the time in the perpendicular, than the space to the space. If therefore in the inclination and perpendicular, we may suppose such spaces and velocities, that the proportion between the said spaces be greater and less than the proportion of the times; we may easily grant, that there are also spaces, by which the times of the motions retain the same proportion as the spaces.

SAGR. I am already freed from my greatest doubt; and conceive that to be not onely possible, but necessary, which I but now thought a contradiction: but nevertheless I understand not as yet, that this whereof we now are speaking, is one of these possible or necessary cases; so as that it should be true, that the time of descent by C A, to the time of the fall by C B, hath the same proportion that the line C A hath to C B; whence it may without contradiction be affirmed, that the velocity by the inclination C A, and by the perpendicular C B, are equal.

SALV. Content your self for this time, that I have removed
your

your incredulity; but for the knowledge of this, expect it at some other time, namely, when you shall see the matters concerning local motion demonstrated by our *Academick*; at which time you shall find it proved, that in the time that the one moveable falls all the space CB , the other descendeth by CA as far as the point T , in which falls the perpendicular drawn from the point B : and to find where the same Cadent by the perpendicular would be when the other arriveth at the point A , draw from A the perpendicular unto CA , continuing it, and CB unto the interfection, and that shall be the point sought. Whereby you see how it is true, that the motion by CB is swifter than by the inclination CA (supposing the term C for the beginning of the motions compared) because the line CB is greater than CT , and the other from C unto the interfection of the perpendicular drawn from A , unto the line CA , is greater than CA , and therefore the motion by it is swifter than by CA . But when we compare the motion made by all CA , not with all the motion made in the same time by the perpendicular continued, but with that made in part of the ~~line~~ ^{by the totc part CB} , it hinders not, that the motion by CA , continuing to descend beyond, may arrive to A in such a time as is in proportion to the other time, as the line CA is to the line CB . Now returning to our first purpose; which was to shew, that the grave moveable leaving its quiescence, passeth descending by all the degrees of tardity, precedent to any whatsoever degree of velocity that it acquireth, re-assuming the same Figure which we used before, let us remember that we did agree, that the Descendent by the inclination CA , and the Cadent by the perpendicular CB , were found to have acquired equal degrees of velocity in the terms B and A : now to proceed, I suppose you will not scruple to grant, that upon another plane less steep than AC ; as for example, AD [in *Fig. 5.*] the motion of the descendent would be yet more slow than in the plane AC . So that it is not any whit dubitable, but that there may be planes so little elevated above the Horizon AB , that the moveable, namely the same ball; in any the longest time may reach the point A , which being to move by the plane AB , an infinite time would not suffice: and the motion is made always more slowly, by how much the declination is less. It must be therefore confessed, that there may be a point taken upon the term B , so near to the said B , that drawing from thence to the point A a plane, the ball would not pass it in a whole year. It is requisite next for you to know, that the *impetus*, namely the degree of velocity the ball is found to have acquired when it arriveth at the point A , is such, that should it continue to move with this self-same degree uniformly, that is to say, without accelerating or retarding;

C

in

in as much more time as it was in coming by the inclining plane, it would pass double the space of the plane inclined: namely (for example) if the ball had past the plane DA in an hour, continuing to move uniformly with that degree of velocity which it is found to have in its arriving at the term A, it shall pass in an hour a space double the length DA; and because (as we have said) the degrees of velocity acquired in the points B and A, by the moveables that depart from any point taken in the perpendicular CB, and that descend, the one by the inclined plane, the other by the said perpendicular, are always equal: therefore the cadent by the perpendicular may depart from a term so near to B, that the degree of velocity acquired in B, would not suffice (still maintaining the same) to conduct the moveable by a space double the length of the plane inclined in a year, nor in ten, nor in a hundred. We may therefore conclude, that if it be true, that according to the ordinary course of nature a moveable, all external and accidental impediments removed, moves upon an inclining plane with greater and greater tardity, according as the inclination shall be less; so that in the end the tardity comes to be infinite, which is, when the inclination concludeth in, and joyneth to the horizontal plane; and if it be true likewise, that the degree of velocity acquired in some point of the inclined plane, is equal to that degree of velocity which is found to be in the moveable that descends by the perpendicular, in the point cut by a parallel to the Horizon, which passeth by that point of the inclining plane; it must of necessity be granted, that the cadent departing from rest, passeth thorow all the infinite degrees of tardity, and that consequently, to acquire a determinate degree of velocity, it is necessary that it move first by right lines, descending by a short or long space, according as the velocity to be acquired, ought to be either less or greater, and according as the plane on which it descendeth is more or less inclined; so that a plane may be given with so small inclination, that to acquire in it the assigned degree of velocity, it must first move in a very great space, and take a very long time; whereupon in the horizontal plane, any how little soever velocity, would never be naturally acquired, since that the moveable in this case will never move: but the motion by the horizontal line, which is neither declined or inclined, is a circular motion about the centre: therefore the circular motion is never acquired naturally, without the right motion precede it; but being once acquired, it will continue perpetually with uniform velocity. I could with other discourses evince and demonstrate the same truth, but I will not by so great a digression interrupt our principal argument: but rather will return to it upon some other occasion; especially since we now assumed the same

The circular motion is never acquired naturally, without right motion precede it. Circular motion perpetually uniform.

same, not to serve for a necessary demonstration, but to adorn a *Platonick* Conceit; to which I will add another particular observation of our *Academick*, which hath in it something of admirable. Let us suppose amongst the decrees of the divine *Architect*, a purpose of creating in the World these Globes, which we behold continually moving round, and of assigning the centre of their conversions; and that in it he had placed the Sun immoveable, and had afterwards made all the said Globes in the same place, and with the intended inclinations of moving towards the Centre; till they had acquired those degrees of velocity, which at first seemed good to the same Divine Minde; the which being acquired, we lastly suppose that they were turned round, each in his Sphere retaining the said acquired velocity: it is now demanded, in what altitude and distance from the Sun the place was where the said Orbs were primarily created; and whether it be possible that they might all be created in the same place? To make this investigation, we must take from the most skilfull Astronomers the magnitude of the Spheres ~~in which the Planets revolve~~, and likewise the time of ~~their~~ revolutions: from which two cognitions is gathered how much (for example) *Jupiter* is swifter than *Saturne*; and being found (as indeed it is) that *Jupiter* moves more swiftly, it is requisite, that departing from the same altitude, *Jupiter* be descended more than *Saturne*, as we really know it is, its Orbe being inferiour to that of *Saturne*. But by proceeding forwards, from the proportions of the two velocities of *Jupiter* and *Saturne*, and from the distance between their Orbs, and from the proportion of acceleration of natural motion, one may finde in what altitude and distance from the centre of their revolutions, was the place from whence they first departed. This found out, and agreed upon, it is to be sought, whether *Mars* descending from thence to his Orb, the magnitude of the Orb, and the velocity of the motion, agree with that which is found by calculation; and let the like be done of the *Earth*, of *Venus*, and of *Mercury*; the greatness of which Spheres, and the velocity of their motions, agree so nearly to what computation gives, that it is very admirable.

The magnitude of the Orbs, and the velocity of the motion of the Planets, answer proportionably, as if descended from the same place.

SAGR. I have hearkened to this conceit with extreme delight; and, but that I believe the making of these calculations truly would be a long and painfull task, and perhaps too hard for me to comprehend, I would make a trial of them.

SALV. The operation indeed is long and difficult; nor could I be certain to finde it so readily; therefore we shall refer it to another time, and for the present we will return to our first proposal, going on there where we made digression; which, if I well remember, was about the proving the motion by a right line of no

Finite and terminate circular motions disorder not the parts of the World.

In the circular motion, every point in the circumference is the beginning and end.

Circular motion only is uniform.

Circular motion may be continued perpetually.

Right motion cannot naturally be perpetual.

Right motion assigned to natural bodies, to reduce them to perfect order, when removed from their places.

Rest only, and circular motion are apt to conserve order.

use, in the ordinate parts of the World; and we did proceed to say, that it was not so in circular motions, of which that which is made by the moveable in it self, still retains it in the same place, and that which carrieth the moveable by the circumference of a circle about its fixed centre, neither puts it self, nor those about it in disorder; for that such a motion primarily is finite and terminate (though not yet finished and determined) but there is no point in the circumference, that is not the first and last term in the circulation; and continuing it in the circumference assigned it, it leaveth all the rest, within and without that, free for the use of others, without ever impeding or disordering them. This being a motion that makes the moveable continually leave, and continually arrive at the end; it alone therefore can primarily be uniform; for that acceleration of motion is made in the moveable, when it goeth towards the term, to which it hath inclination; and the retardation happens by the repugnance that it hath to leave and part from the same term; and because in circular motion, the moveable continually leaves the natural term, and continually moveth towards the same; therefore, in it, the repugnance and inclination are always of equal force: from which equality results a velocity, neither retarded nor accelerated, i. e. an uniformity in motion. From this conformity, and from the being terminate, may follow the perpetual continuation by successively reiterating the circulations; which in an undetermined line, and in a motion continually retarded or accelerated, cannot naturally be. I say, naturally; because the right motion which is retarded, is the violent, which cannot be perpetual; and the accelerate arriveth necessarily at the term, if one there be; and if there be none, it cannot be moved to it, because nature moves not whether it is impossible to attain. I conclude therefore, that the circular motion can only naturally consist with natural bodies, parts of the universe, and constituted in an excellent disposition; and that the right, at the most that can be said for it, is assigned by nature to its bodies, and their parts, at such time as they shall be out of their proper places, constituted in a depraved disposition, and for that cause needing to be reduced by the shortest way to their natural state. Hence, me thinks, it may rationally be concluded, that for maintenance of perfect order amongst the parts of the World, it is necessary to say, that moveables are moveable only circularly; and if there be any that move not circularly, these of necessity are immoveable: there being nothing but rest and circular motion apt to the conservation of order. And I do not a little wonder with my self, that Aristotle, who held that the Terrestrial globe was placed in the centre of the World, and there remained immoveable, should not say, that

of

of natural bodies some are moveable by nature; and others immoveable; especially having before defined Nature, to be the principle of Motion and Rest.

SIMPL. Aristotle, though of a very perspicacious wit, would not strain it further than needed: holding in all his arguments, that sensible experiments were to be preferred before any reasons founded upon strength of wit; and said those which should deny the testimony of sense deserved to be punished with the loss of that sense; now who is so blind, that sees not the parts of the Earth and Water to move, as being grave, naturally downwards, namely, towards the centre of the Universe, assigned by nature her self for the end and term of right motion *deorsum*; and doth not likewise see the Fire and Air to move right upwards towards the Concave of the Lunar Orb, as to the natural end of motion *sursum*? And this being so manifestly seen, and we being certain, that *eadem est ratio totius & partium*, why may we not assert it for a true and manifest proposition, that the natural motion of the Earth is the right motion *ad medium*, and that of the Fire, the right *a medio*?

SALV. The most that you can pretend from this your Discourse, were it granted to be true, is that, like as the parts of the Earth removed from the whole, namely, from the place where they naturally rest, that is in short reduced to a depraved and disordered disposeure, return to their place spontaneously, and therefore naturally in a right motion; (it being granted, that *eadem sit ratio totius & partium*) so it may be inferred, that the Terrestrial Globe removed violently from the place assigned it by nature, it would return by a right line. This, as I have said, is the most that can be granted you; and that onely for want of examination; but he that shall with exactness revise these things, will first deny, that the parts of the Earth, in returning to its whole, move in a right line, and not by a circular or mixt; and really you would have enough to do to demonstrate the contrary, as you shall plainly see in the answers to the particular reasons and experiments alledged by Ptolomey and Aristotle. Secondly, If another should say that the parts of the Earth, go not in their motion towards the Centre of the World, but to unite with its Whole, and that for that reason they naturally incline towards the centre of the Terrestrial Globe, by which inclination they conspire to form and preserve it, what other All, or what other Centre would you find for the World, to which the whole Terrene Globe, being thence removed, would seek to return, that so the reason of the Whole might be like to that of its parts? It may be added, That neither Aristotle, nor you can ever prove, that the Earth *de facto* is in the centre of the Universe; but if any Centre may

Sensible experiments are to be preferred before humane argumentations.

He who denies sense, deserves to be deprived of it.

Sense sheweth that things grave move to the medium, and the light to the concave.

It is questionable whether descending weights move in a right line.

The Earth spirital by the conspiration of its parts to its Centre.

The Sun more probably in the centre of the Universe, than the Earth. may be assigned to the Universe, we shall rather find the Sun placed in it, as by the sequel you shall understand.

Natural inclination of the parts of all the globes of the World to go to their centre.

Now, like as from the consentaneous conspiracy of all the parts of the Earth to form its whole, doth follow, that they with equal inclination concurr thither from all parts; and to unite themselves as much as is possible together, they there spherically adapt themselves; why may we not believe that the Sun, Moon, and other mundane Bodies, be also of a round figure, not by other than a concordant instinct, and natural concurrence of all the parts composing them? Of which, if any, at any time, by any violence were separated from the whole, is it not reasonable to think, that they would spontaneously and by natural instinct return? and in this manner to infer, that the right motion agreeth with all mundane bodies alike.

The right motion of grave bodies manifest to sense.

SIMPL. Certainly, if you in this manner deny not only the Principles of Sciences, but manifest Experience, and the Senses themselves, you can never be convinced or removed from any opinion which you once conceit, therefore I will choose rather to be silent (*for, contra negantes principia non est disputandum*) than contend with you. And insisting on the things alledged by you even now (since you question so much as whether grave moveables have a right motion or no) how can you ever rationally deny, that the parts of the Earth; or, if you will, that ponderous matters descend towards the Centre, with a right motion; when, as, if from a very high Tower, whose walls are very upright and perpendicular, you let them fall, they shall descend gliding and sliding by the Tower to the Earth, exactly in that very place where a plummet would fall, being hanged by a line fastned above, just there, whence the said weights were let fall? is not this a more than evident argument of the motions being right, and towards the Centre? In the second place you call in doubt, whether the parts of the Earth are moved, as *Aristotle* affirms, towards the Centre of the World; as if he had not rationally demonstrated it by contrary motions, whilst he thus argueth; The motion of heavie bodies is contrary to that of the light: but the motion of the light is manifest to be directly upwards, namely, towards the circumference of the World, therefore the motion of the heavie is directly towards the Centre of the World: and it happens *per accidens*, that it be towards the centre of the Earth, for that this striveth to be united to that. The seeking in the next place, what a part of the Globe of the Sun or Moon would do, were it separated from its whole, is vanity; because that thereby that is sought, which would be the consequence of an impossibility; in regard that, as *Aristotle* also demonstrates, the celestial bodies are impassible, impenetrable, and infrangible; so that such a case

Arguments of Aristotle, to prove that grave bodies move with an inclination to arrive at the centre of the Universe.

Heavie bodies move towards the centre of the Earth per accidens.

To seek what would follow upon an impossibility, is folly.

a case can never happen: and though it should, and that the separated part should return to its whole, it would not return as grave or light, for that the same *Aristotle* proveth, that the Cælestial Bodies are neither heavie nor light.

Cælestial bodies neither heavie nor light, according to Aristotle.

SALV. With what reason I doubt, whether grave bodies move by a right and perpendicular line, you shall hear, as I said before, when I shall examine this particular argument. Touching the second point, I wonder that you should need to discover the *Paralogism* of *Aristotle*, being of it self so manifest; and that you perceive not, that *Aristotle* supposeth that which is in question: therefore take notice.

SIMPL. Pray *Salvatus* speak with more respect of *Aristotle*: for who can you ever perswade, that he who was the first, only, and admirable explainer of the *Syllogistick* forms of demonstration, of *Elenchs*, of the manner of discovering *Sophisms*, *Paralogisms*, and in short, of all the parts of *Logick*, should afterwards so notoriously equivocate in imposing that for known, which is in question? It would be better, my Masters, first perfectly to understand him, and then to try, if you have ~~any~~ *quote him*.

Aristotle cannot equivocate, being the inventor of Logick.

SALV. *Simplivius*, We are here familiarly discoursing among our selves, to investigate some truth; I shall not be displeased that you discover my errors; and if I do not follow the mind of *Aristotle*, freely reprehend me, and I shall take it in good part. Onely give me leave to expound my doubts, and to reply something to your last words, telling you, that *Logick*, as it is well understood, is the Organe with which we philosophate; but as it may be possible, that an Artist may be excellent in making Organs, but unlearned in playing on them, thus he might be a great Logician, but unexpert in making use of *Logick*; like as we have many that theoretically understand the whole Art of Poetry, and yet are unfortunate in composing but meer four Verses; others enjoy all the precepts of *Vinci*, and yet know not how to paint a Stool. The playing on the Organs is not taught by them who know how to make Organs, but by him that knows how to play on them: Poetry is learnt by continual reading of Poets: Limning is learnt by continual painting and designing: Demonstration from the reading of Books full of demonstrations, which are the Mathematical onely, and not the Logical. Now returning to our purpose, I say, that that which *Aristotle* seeth of the motion of light bodies, is the departing of the Fire from any part of the Superficies of the Terrestrial Globe, and directly retreating from it, mounting upwards; and this indeed is to move towards a circumference greater than that of the Earth; yea, the same *Aristotle* makes it to move to the concave of the Moon, but that this circumference is that of the World, or concentrick to it, so that

A famous Italian Painter.

Paralogism of Aristotle, in proving the Earth to be in the Centre of the World.

The Paralogisme of Aristotle another way discovered.

that to move towards this, is a moving towards that of the World, that he cannot affirm, unless he supposeth, That the Centre of the Earth, from which we see these light ascendent bodies to depart, be the same with the Centre of the World; which is as much as to say, that the terrestrial Globe is constituted in the midst of the World: which is yet that of which we were in doubt, and which *Aristotle* intended to prove. And do you say that this is not a manifest *Paralogism*?

SAGR. This Argument of *Aristotle* appeared to me deficient also, and non-concludent for another respect; though it were granted, that that Circumference, to which the Fire directly moveth, be that which includeth the World: for that in a circle, not onely the centre, but any other point being taken, every moveable which departing thence, shall move in a right line, and towards any whatsoever part, shall without any doubt go towards the circumference, and continuing the motion, shall also arrive thither; so that we may truly say, that it moveth towards the circumference: but yet it doth not follow, that that which moveth by the same line with a contrary motion, would go towards the centre, unless when the point taken were the centre it self, or that the motion were made by that onely line, which produced from the point assigned, passeth thorow the centre. So that to say, that Fire moving in a right line, goeth towards the circumference of the World, therefore the parts of the Earth which by the same lines move with a contrary motion, go towards the centre of the World, concludeth not, unless then when it is presupposed, that the lines of the Fire prolonged pass by the centre of the World; and because we know certainly of them, that they pass by the centre of the Terrestrial Globe (being perpendicular to its superficies, and not inclined) therefore to conclude, it must be supposed, that the centre of the Earth is the same with the centre of the World; or at least, that the parts of the Fire and Earth descend not, save onely by one sole line which passeth by the centre of the World. Which nevertheless is false, and repugnant to experience, which sheweth us, that the parts of Fire, not by one line onely, but by infinite, produced from the centre of the Earth towards all the parts of the World, ascend always by lines perpendicular to the Superficies of the Terrestrial Globe.

SALV. You do very ingeniously lead *Aristotle* to the same inconvenience, *Sagredus*, shewing his manifest equivoke; but withal you add another inconsistency. We see the Earth to be spherical, and therefore are certain that it hath its centre, to which we see all its parts are moved; for so we must say, whilst their motions are all perpendicular to the Superficies of the Earth; we mean,

mean, that as they move to the centre of the Earth, they move to their *Whole*, and to their Universal Mother: and we are still farther so free, that we will suffer our selves to be perswaded, that their natural instinct is, not to go towards the centre of the Earth, but towards that of the Universe; which we know not where to find, or whether it be or no; and were it granted to be, it is but an imaginary point, and a nothing without any quality. As to what *Simplicius* said last, that the contending whether the parts of the Sun, Moon, or other cœlestial Body, separated from their *Whole*, should naturally return to it, is a vanity, for that the case is impossible; it being clear by the Demonstrations of *Aristotle*, that the cœlestial Bodies are impassible, impenetrable, unpartable, &c. I answer, that none of the conditions, whereby *Aristotle* distinguisheth the Cœlestial Bodies from Elementary, hath other foundation than what he deduceth from the diversity of the natural motion of those and these; insomuch that it being denied, that the circular motion is peculiar to Cœlestial Bodies, and affirmed, that it is agreeable to Bodies naturally moveable, it is behoofull upon necessary consequence to say, either that the attributes of generable, or ingenerable, alterable, or unalterable, partable, or unpartable, &c. equally and commonly agree with all worldly bodies, namely, as well to the Cœlestial as to the Elementary; or that *Aristotle* hath badly and erroneously deduced those from the circular motion, which he hath assigned to Cœlestial Bodies.

Grave bodies may more rationally be affirmed to tend to the Centre of the Earth, than of the Universe.

The conditions and attributes which differ the cœlestial bodies from Elementary, depend on the motions assigned them by Aristotle.

SIMPL. This manner of argumentation tends to the subversion of all Natural Philosophy, and to the disorder and subversion of Heaven and Earth, and the whole Universe; but I believe the Fundamentals of the *Peripateticks* are such, that we need not fear that new Sciences can be erected upon their ruines.

SALV. Take no thought in this place for Heaven or the Earth, neither fear their subversion, or the ruine of Philosophy. As to Heaven, your fears are vain for that which you your self hold unalterable and impassible; as for the Earth, we strive to enoble and perfect it, whilst we make it like to the Cœlestial Bodies, and as it were place it in Heaven, whence your Philosophers have exiled it. Philosophy it self cannot but receive benefit from our Disputes, for if our conceptions prove true, new Discoveries will be made; if false, the first Doctrine will be more confirmed. Rather bestow your care upon some Philosophers, and help and defend them; for as to the Science it self, it cannot but improve. And that we may return to our purpose, be pleased freely to produce what presents it self to you in confirmation of that great difference which *Aristotle* puts between the Cœlestial Bodies, and the Elementary parts of the World, in making those ingenerable,

The disputes and contradictions of Philosophers may conduce to the benefit of Philosophy.

D

incor-

incorruptible, unalterable, &c. and this corruptible, alterable, &c.

SIMPL. I see not yet any need that *Aristotle* hath of help, standing as he doth stoutly and strongly on his feet; yea not being yet assaulted, much less foiled by you. And what ward will

Aristotles discourse to prove the incorruptibility of Heaven.

Generation & corruption is onely amongst contraries, according to Arist.

To the circular motion no other motion is contrary.

Heaven an habitation for the immortal Gods.

Immutability of Heaven evident to sense.

He proveth that the circular motion hath no contrary.

you choole in this combate for this first blow? *Aristotle* writeth, that whatever is generated, is made out of a contrary in some subject, and likewise is corrupted in some certain subject from a contrary into a contrary; so that (observe) corruption and generation is never but onely in contraries; If therefore to a Cœlestial Body no contrary can be assigned, for that to the circular motion no other motion is contrary, then Nature hath done very well to make that exempt from contraries, which was to be ingenerable and incorruptible; This fundamental first confirmed, it immediately followeth of consequence, that it is inaugmentable, unalterable, impassible, and finally eternal, and a proportionate habitation to the immortal Deities, conformable to the opinion even of all men that have any conceit of the Gods. He afterwards confirmeth the same by sense; in regard, that in all times past, according to memory or tradition, we see nothing removed, according to the whole outward Heaven, nor any of its proper parts. Next, as to the circular motion, that no other is contrary to it, *Aristotle* proveth many ways; but without reciting them all, it is sufficiently demonstrated, since simple motions are but three, to the *medium*, from the *medium*, and about the *medium*, of which the two right, *sursum* and *deorsum*, are manifestly contrary; and because one onely hath onely one for contrary, therefore there rests no other motion which may be contrary to the circular. You see the subtle and most concluding discourse of *Aristotle*, whereby he proveth the incorruptibility of Heaven.

SALV. This is nothing more; save the pure progress of *Aristotle*, by me hinted before; wherein, besides that I affirm, that the motion which you attribute to the Cœlestial Bodies agreeth also to the Earth, its illation proves nothing. I tell you therefore, that that circular motion which you assign to Cœlestial Bodies, suiteth also to the Earth, from which, supposing that the rest of your discourse were concludent, will follow one of these three things; as I told you a little before; and shall repeat; namely, either that the Earth it self is also ingenerable, and incorruptible, as the Cœlestial bodies; or that the Cœlestial bodies are, like as the Elementary generable, alterable &c. or that this difference of motion hath nothing to do with Generation and Corruption. The discourse of *Aristotle*, and yours also contain many Propositions not to be lightly admitted, and the better to examine them; it will be convenient to reduce them to the most abstracted and distinct

distinct that can be possible; and excuse me *Sagredus*, if haply with some tediousness you hear me oft repeat the same things, and fancie that you see me reassume my argument in the publick circle of Disputations. You say Generation and Corruption are onely made where there are contraries; contraries are onely amongst simple natural bodies, moveable with contrary motions; contrary motions are onely those which are made by a right line between contrary terms; and these are onely two, that is to say, from the *medium*, and towards the *medium*; and such motions belong to no other natural bodies, but to the *Earth*, the *Fire*, and the other two Elements: therefore Generation and Corruption is onely amongst the Elements. And because the third simple motion, namely, the circular about the *medium*, hath no contrary, (for that the other two are contraries, and one onely, hath but onely one contrary) therefore that natural body with which such motion agreeth, wants a contrary; and having no contrary is ingenerable and incorruptible, &c. Because where there is no contrariety, there is no generation or corruption, &c. But such motion agreeth onely with the Cœlestial bodies; therefore onely these are ingenerable, incorruptible, &c. And to begin, I think it a more easie thing, and sooner done to resolve, whether the *Earth* (a most vast Body, and for its vicinity to us, most tractable) moveth with a speedy motion, such as its revolution about its own axis in twenty four hours would be, than it is to understand and resolve, whether Generation and Corruption ariseth from contrariety, or else whether there be such things as generation, corruption and contrariety in nature. And if you, *Simplicius*, can tell me what method Nature observes in working, when she in a very short time begets an infinite number of flies from a little vapour of the Must of wine, and can shew me which are there the contraries you speak of, what it is that corrupteth, and how; I should think you would do more than I can; for I profess I cannot comprehend these things. Besides, I would very gladly understand how, and why these corruptive contraries are so favourable to Daws, and so cruel to Doves; so indulgent to Stags, and so hasty to Horses, that they do grant to them many more years of life, that is, of incorruptibility, than weeks to these. Peaches and Olives are planted in the same soil, exposed to the same heat and cold, to the same wind and rains, and, in a word, to the same contrarieties; and yet those decay in a short time, and these live many hundred years. Furthermore, I never was thorowly satisfied about this substantial transmutation (still keeping within pure natural bounds) whereby a matter becometh so transform'd, that it should be necessarily said to be destroy'd, so that nothing remaineth of its first being, and that another body

Its easier to prove the Earth to move, than that corruption is made by contraries.

Bare transposition
of parts may repre-
sent bodies under
diverse aspects.

quite differing there-from should be thence produced; and if I fancy to my self a body under one aspect, and by and by under another very different, I cannot think it impossible but that it may happen by a simple transposition of parts, without corrupting or ingendring any thing a-new; for we see such kinds of Metamorphoses dayly: so that to return to my purpose, I answer you, that inasmuch as you go about to perswade me that the Earth can not move circularly by way of corruptibility and generability, you have undertook a much harder task than I, that with arguments more difficult indeed, but no less concluding, will prove the contrary.

SAGR. Pardon me, *Salviatus*, if I interrupt your discourse, which, as it delights me much, for that I also am gravel'd with the same doubts; so I fear that you can never conclude the same, without altogether digressing from your chief design: therefore if it be permitted to proceed in our first argument, I should think that it were convenient to remit this question of generation and corruption to another distinct and single conference; as also, if it shall please you and *Simplicius*, we may do by other particular questions which may fall in the way of our discourse; which I will keep in my mind to propose, and exactly discuss them some other time. Now as for the present, since you say, that if *Aristotle* deny circular motion to the Earth in common with other bodies Cœlestial, it thence will follow, that the same which befallerh the Earth, as to its being generable, alterable, &c. will hold also of Heaven; let us enquire no further if there be such things in nature, as generation and corruption, or not; but let us return to enquire what the Globe of the Earth doth.

By denying Prin-
ciples in the Scien-
ces, any Paradox
may be maintain-
ed.

SIMPL. I cannot suffer my ears to hear it question'd, whether generation and corruption be in *rarum naturā*, it being a thing which we have continually before our eyes, and whereof *Aristotle* hath written two whole Books. But if you go about to deny the Principles of Sciences, and question things most manifest, who knows not, but that you may prove what you will, and maintain any Paradox? And if you do not dayly see herbs, plants, animals to generate and corrupt, what is it that you do see? Also, do you not continually behold contrarieties contend together, and the Earth change into Water, the Water turn to Air, the Air into Fire, and again the Air to condense into Clouds, Rains, Hails and Storms?

SAGR. Yes, we see these things indeed, and therefore will grant you the discourse of *Aristotle*, as to this part of generation and corruption made by contraries; but if I shall conclude by virtue of the same propositions which are granted to *Aristotle*, that the Cœlestial bodies themselves are also generable and corruptible

ruptible, aswell as the Elementary, what will you say then?

SIMPL. I will say you have done that which is impossible to be done.

SAGR. Go to; tell me, *Simplicius*, are not these affections contrary to one another?

SIMPL. Which?

SAGR. Why these; Alterable, unalterable; passible, *impas-
fible; generable, ingenerable; corruptible, incorruptible?

SIMPL. They are most contrary.

SAGR. Well then, if this be true, and it be also granted, that Cœlestial Bodies are ingenerable and incorruptible; I prove that of necessity Cœlestial Bodies must be generable and corruptible.

SIMPL. This must needs be a *Sophism*.

SAGR. Hear my Argument, and then censure and resolve it. Cœlestial Bodies, for that they are ingenerable and incorruptible, have in Nature their contraries, which are those Bodies that be generable and corruptible. Cœlestial Bodies are generable and corruptible, because they are ingenerable and incorruptible. ~~When there is contrariety, there is also generation and corruption; therefore Cœlestial Bodies are generable and corruptible.~~

SIMPL. Did I not say it could be no other than a *Sophism*?

This is one of those forked Arguments called *Sorita*: like that of the *Cretan*, who said that all *Cretans* were liars; but he as being a *Cretan*, had told a lye; in saying that the *Cretans* were liars; it followed therefore, that the *Cretans* were no liars; and consequently that he, as being a *Cretan*, had spoke truth: And yet in saying the *Cretans* were liars, he had said true, and comprehending himself as a *Cretan*, he must consequently be a liar. And thus in these kinds of *Sophisms* a man may dwell to eternity, and never come to any conclusion. The forked Syllogism call'd Soritis.

SAGR. You have hitherto censured it, it remaineth now that you answer it, shewing the fallacie.

SIMPL. As to the resolving of it, and finding out its fallacie, do you not in the first place see a manifest contradiction in it? Cœlestial Bodies are ingenerable and incorruptible; Ergo, Cœlestial Bodies are generable and corruptible. And again, the contrariety is not betwixt the Cœlestial Bodies, but betwixt the Elements, which have the contrariety of the Motions, *sursum* and *deorsum*, and of levity and gravity; But the Heavens which move circularly, to which motion no other motion is contrary, want contrariety, and therefore they are incorruptible.

SAGR. Fair and softly, *Simplicius*; this contrariety whereby you say some simple Bodies become corruptible, resides it in the same Body which is corrupted, or else hath it relation to some other? I say, for example, the humidity by which a piece of Earth

is

Amongst Cœlestial Bodies there is no contrariety.

is corrupted, resides it in the same Earth or in some other bodie, which must either be the Air or Water? I believe you will grant, that like as the Motions upwards and downwards, and gravity and levity, which you make the first contraries, cannot be in the same Subject, so neither can moist and dry, hot and cold: you must therefore consequently acknowledg that when a bodie corrupteth, it is occasioned by some quality residing in another contrary to its own: therefore to make the Cœlestial Body become corruptible, it sufficeth that there are in Nature, bodies that have a contrariety to that Cœlestial body; and such are the Elements, if it be true that corruptibility be contrary to incorruptibility.

Contraries which are the causes of corruption, reside not in the same body that corrupteth.

SIMPL. This sufficeth not, Sir; The Elements alter and corrupt, because they are intermixed, and are joyn'd to one another, and so may exercise their contrariety; but Cœlestial bodies are separated from the Elements, by which they are not so much as toucht, though indeed they have an influence upon the Elements. It is requisite, if you will prove generation and corruption in Cœlestial bodies, that you shew, that there resides contrarieties between them.

Cœlestial Bodies touch, but are not touched by the Elements.

Gravity & levity, rarity and density, are contrary qualities.

The stars infinitely surpass the substance of the rest of Heaven in density.

Rarity & density in Cœlestial bodies, is different from the rarity & density of the elements.

SAGR. See how I will find those contrarieties between them. The first fountain from whence you derive the contrariety of the Elements, is the contrariety of their motions upwards and downwards: it therefore is necessary that those Principles be in like manner contraries to each other, upon which those motions depend: and because that is moveable upwards by lightness, and this downwards by gravity, it is necessary that lightness and gravity are contrary to each other: no less are we to believe those other Principles to be contraries, which are the causes that this is heavy, and that light: but by your own confession, levity and gravity follow as consequents of rarity and density; therefore rarity and density shall be contraries: the which conditions or affections are so amply found in Cœlestial bodies, that you esteem the stars to be onely more dense parts of their Heaven: and if this be so, it followeth that the density of the stars exceeds that of the rest of Heaven, by almost infinite degrees: which is manifest, in that Heaven is infinitely transparent, and the stars extremely opacous; and for that there are there above no other qualities, but more and less density and rarity, which may be causes of the greater or less transparency. There being then such contrariety between the Cœlestial bodies, it is necessary that they also be generable and corruptible, in the same manner as the Elementary bodies are; or else that contrariety is not the cause of corruptibility, &c.

SIMPL. There is no necessity either of one or the other, for that density and rarity in Cœlestial bodies, are not contraries to each

each other, as in Elementary bodies; for that they depend not on the primary qualities, cold and heat, which are contraries; but on the more or less matter in proportion to quantity: now much and little, speak onely a relative opposition, that is, the least of oppositions, and which hath nothing to do with generation and corruption.

SAGR. Therefore affirming, that density and rarity, which amongst the Elements should be the cause of gravity and levity, which may be the causes of contrary motions *sursum* and *deorsum*, on which, again, dependeth the contrarieties for generation and corruption; it sufficeth not that they be those densenesses and rarenesses which under the same quantity, or (if you will) mass contain much or little matter, but it is necessary that they be densenesses and rarenesses caused by the primary qualities, hot and cold, otherwise they would operate nothing at all: but if this be so, Aristotle hath deceived us, for that he should have told it us at first, and so have left written that those simple bodies are generable and corruptible, that ~~are~~ ^{are} ~~movable~~ with simple motions upwards and downwards, dependent on levity and gravity, caused by rarity and density, made by much or little matter, by reason of heat and cold; and not to have staid at the simple motion *sursum* and *deorsum*: for I assure you that to the making of bodies heavy or light, whereby they come to be moved with contrary motions, any kind of density and rarity sufficeth, whether it proceed from heat and cold, or what else you please; for heat and cold have nothing to do in this affair: and you shall upon experiment find, that a red hot iron, which you must grant to have heat, weigheth as much, and moves in the same manner as when it is cold. But to overpass this also, how know you but that Cœlestial rarity and density depend on heat and cold?

Aristotle defective in assigning the causes why the elements are generable & corruptible.

SIMPL. I know it, because those qualities are not amongst Cœlestial bodies, which are neither hot nor cold.

SALV. I see we are again going about to engulph our selves in a bottomless ocean, where there is no getting to shore; for this is a Navigation without Compass, Stars, Oars or Rudder: so that it will follow either that we be forced to pass from Shelf to Shelf, or run on ground, or to sail continually in danger of being lost. Therefore, if according to your advice we shall proceed in our main design, we must of necessity for the present overpass this general consideration, whether direct motion be necessary in Nature, and agree with some bodies; and come to the particular demonstrations, observations and experiments; propounding in the first place all those that have been hitherto alledged by Aristotle, Ptolomey, and others, to prove the stability of the Earth, endeavouring in the next place to answer them: and producing in the

the last place, those, by which others may be perswaded, that the Earth is no less than the Moon, or any other Planet to be numbered amongst natural bodies that move circularly.

SAGR. I shall the more willingly incline to this, in that I am better satisfied with your Architectonical and general discourse, than with that of *Aristotle*, for yours convinceth me without the least scruple, and the other at every step crosseth my way with some block. And I see no reason why *Simplicius* should not be presently satisfied with the Argument you alledg, to prove that there can be no such thing in nature as a motion by a right line, if we do but presuppose that the parts of the Universe are disposed in an excellent constitution and perfect order.

SALV. Stay a little, good *Sagredus*, for just now a way comes into my mind, how I may give *Simplicius* satisfaction, provided that he will not be so strictly wedded to every expression of *Aristotle*, as to hold it heresie to recede in any thing from him. Nor is there any question to be made, but that if we grant the excellent disposition and perfect order of the parts of the Universe, as to local scituation, that then there is no other but the circular motion, and rest; for as to the motion by a right line, I see not how it can be of use for any thing, but to reduce to their natural constitution, some integral bodies, that by some accident were remov'd and separated from their whole, as we said above.

Let us now consider the whole Terrestrial Globe, and enquire the best we can, whether it, and the other Mundane bodies are to conserve themselves in their perfect and natural disposition. It is necessary to say, either that it rests and keeps perpetually immoveable in its place; or else that continuing always in its place, it revolves in its self; or that it turneth about a Centre, moving

Arist. & Ptolomey make the Terrestrial Globe immoveable.

It is better to say, that the Terrestrial Globe naturally resteth, than that it moveth directly downwards.

**The word is, alligari, which the Latine version rendereth sursum, which is quite contrary to the Authors sense.*

by the circumference of a circle. Of which accidents, both *Aristotle* and *Ptolomey*, and all their followers say, that it hath ever observed, and shall continually keep the first, that is, a perpetual rest in the same place. Now, why, I pray you, ought they not to have said, that its natural affection is to rest immoveable, rather than to make natural unto it the motion * downwards, with which motion it never did or shall move? And as to the motion by a right line, they must grant us that Nature maketh use of it to reduce the small parts of the Earth, Water, Air, Fire, and every other integral Mundane body to their *Whole*, when any of them by chance are separated, and so transported out of their proper place; if also haply, some circular motion might not be found to be more convenient to make this restitution. In my judgment, this primary position answers much better, even according to *Aristotles* own method, to all the other consequences, than to attribute the straight motion to be an intrinsic and natural principle

principle of the Elements. Which is manifest, for that if I aske the *Peripatetick*, if, being of opinion that Cœlestial bodies are incorruptible and eternal, he believeth that the Terrestrial Globe is not so, but corruptible and mortal, so that there shall come a time, when the Sun and Moon and other Stars, continuing their beings and operations, the Earth shall not be found in the World, but shall with the rest of the Elements be destroyed and annihilated, I am certain that he would answer me, no: therefore generation and corruption is in the parts and not in the whole; and in the parts very small and superficial, which are, as it were, incensibile in comparison of the whole masse. And because *Aristotle* deduceth generation and corruption from the contrariety of streight motions, let us remit such motions to the parts, which onely change and decay, and to the whole Globe and Sphere of the Elements, let us ascribe either the circular motion, or a perpetual consistence in its proper place: the only affections apt for perpetuation, and maintaining of perfect order. This which is spoken of the Earth, may be said with the same reason of Fire, and of the greatest part of the Air; to which Elements, the *Peripateticks* are forced to ascribe for intrinsical and natural, a motion wherewith they were never yet moved, nor never shall be; and to call that motion preternatural to them, wherewith, if they move at all, they do and ever shall move. This I say, because they assign to the Air and Fire the motion upwards, wherewith those Elements were never moved, but only some parts of them, and those were so moved onely in order to the recovery of their perfect constitution, when they were out of their natural places; and on the contrary they call the circular motion preternatural to them, though they are thereby incessantly moved: forgetting, as it seemeth, what *Aristotle* oft inculcatedh, that nothing violent can be permanent.

SIMPL. To all these we have very pertinent answers, which I for this time omit, that we may come to the more particular reasons, and sensible experiments, which ought in conclusion to be opposed, as *Aristotle* saith well, to whatever humane reason can present us with.

SAGR. What hath been spoken hitherto, serves to clear up unto us which of the two general discourses carrieth with it most of probability, I mean that of *Aristotle*, which would perswade us, that the sublunary bodies are by nature generable, and corruptible, &c. and therefore most different from the essence of Cœlestial bodies, which are impassible, ingenerable, incorruptible, &c. drawn from the diversity of simple motions; or else this of *Salviatus*, who supposing the integral parts of the World to be disposed in a perfect constitution, excludes by necessary consequence

Right Motion with more reason attributed to the parts, than to the whole Elements.

The Peripateticks improperly assign those motions to the Elements for Natural, with which they never were moved, and those for Preternatural with which they alwayes are moved.

Sensible experiments to be preferred to humane Arguments.

E

quence

quence the right or straight motion of simple natural bodies, as being of no use in nature, and esteems the Earth it self also to be one of the Cœlestial bodies adorn'd with all the prerogatives that agree with them; which last discourse is hitherto much more likely, in my judgment, than that other. Therefore resolve, *Simplicius*, to produce all the particular reasons, experiments and observations, as well Natural as Astronomical, that may serve to perswade us that the Earth differeth from the Cœlestial bodies, is immoveable, and situated in the Centre of the World, and what ever else excludes its moving like to the Planets, as *Jupiter* or the *Moon*, &c. And *Salviatus* will be pleased to be so civil as to answer to them one by one.

SIMPL. See here for a begining, two most convincing Arguments to demonstrate the Earth to be most different from the Cœlestial bodies. First, the bodies that are generable, corruptible, alterable, &c. are quite different from those that are ingenerable, incorruptible, unalterable, &c. But the Earth is generable, corruptible, alterable, &c. and the Cœlestial bodies ingenerable, incorruptible, unalterable, &c. Therefore the Earth is quite different from the Cœlestial bodies.

SAGR. By your first Argument you spread the Table with the same Viands, which but just now with much adoe were voided.

SIMPL. Hold a little, Sir, and take the rest along with you, and then tell me if this be not different from what you had before. In the former, the *Minor* was proved *à priori*, & now you see it proved *à posteriori*: Judg then if it be the same. I prove the *Minor*, therefore (the *Major* being most manifest) by sensible experience, which shews us that in the Earth there are made continual generations, corruptions, alterations, &c. which neither our senses, nor the traditions or memories of our Ancestors, ever saw an instance of in Heaven; therefore Heaven is unalterable, &c. and the Earth alterable, &c. and therefore different from Heaven. I take my second Argument from a principal and essential accident, and it is this. That body which is by its nature obscure and deprived of light, is divers from the luminous and shining bodies; but the Earth is obscure and void of light, and the Cœlestial bodies splendid, and full of light; Ergo, &c. Answer to these Arguments first; that we may not heap up too many, and then I will alledge others.

Heaven immutable, because there never was any mutation seen in it.

Bodies naturally lucid, are different from those which are by nature obscure.

SALV. As to the first, the stress whereof you lay upon experience, I desire that you would a little more distinctly produce me the alteration which you see made in the Earth, and not in Heaven; upon which you call the Earth alterable, and the Heavens not so.

SIMPL. I see in the Earth, plants and animals continually generating

nerating and decaying; winds, rains, tempests, storms arising; and in a word, the aspect of the Earth to be perpetually metamorphosing; none of which mutations are to be discern'd in the Cœlestial bodies; the constitution and figuration of which is most punctually conformable to that they ever were time out of mind; without the generation of any thing that is new, or corruption of any thing that was old.

SALV. But if you content your self with these visible, or to say better, seen experiments, you must consequently account *China* and *America* Cœlestial bodies, for doubtlesse you never beheld in them these alterations which you see here in *Italy*, and that therefore according to your apprehension they are inalterable.

SIMPL. Though I never did see these alterations sensibly in those places, the relations of them are not to be questioned; besides that, *cum eadem sit ratio totius, & partium*, those Countreys being a part of the Earth, as well as ours, they must of necessity be alterable as these are.

SALV. And why have you not, without being put to believe other mens relations, examined and observed those alterations with your own eyes?

SIMPL. Because those places, besides that they are not exposed to our eyes, are so remote, that our sight cannot reach to comprehend therein such like mutations.

SALV. See now, how you have unawares discovered the fallacy of your Argument; for, if you say that the alterations that are seen on the Earth neer at hand, cannot, by reason of the too great distance, be seen in *America*, much lesse can you see them in the Moon, which is so many hundred times more remote: And if you believe the alterations in *Mexico* upon the report of those that come from thence, what intelligence have you from the Moon, to assure you that there is no such alterations in it? Therefore, from your not seeing any alterations in Heaven, whereas, if there were any such, you could not see them by reason of their too great distance, and from your not having intelligence thereof, in regard that it cannot be had, you ought not to argue, that there are no such alterations; howbeit, from the seeing and observing of them on Earth, you well argue that therein such there are.

SIMPL. I will shew so great mutations that have befall on the Earth; that if any such had happened in the Moon, they might very well have been observed here below. We find in very antient records, that heretofore at the Streights of *Gibraltar*, the two great Mountains *Abila*, and *Calpen*, were continued together by certain other lesse Mountains, which there gave check

The Mediterranean Sea made by the separation of Abila and Calpen.

to the Ocean: but those Hills, being by some cause or other separated, and a way being opened for the Sea to break in, it made such an inundation, that it gave occasion to the calling of it since the Mid-land Sea: the greatness whereof considered, and the divers aspects the surfaces of the Water and Earth then made, had it been beheld afar off, there is no doubt but so great a change might have been discerned by one that was then in the Moon; as also to us inhabitants of the Earth, the like alterations would be perceived in the Moon; but we find not in antiquity, that ever there was such a thing seen; therefore we have no cause to say, that any of the Cœlestial bodies are alterable, &c.

SALV. That so great alterations have hapned in the Moon, I dare not say, but for all that, I am not yet certain but that such changes might occur; and because such a mutation could onely represent unto us some kind of variation between the more clear, and more obscure parts of the Moon; I know not whether we have had on Earth observant Selenographers, who have for any considerable number of years, instructed us with so exact Selenography, as that we should confidently conclude, that there hath no such change hapned in the face of the Moon; of the figuration of which I find no more particular description, than the saying of some, that it represents an humane face; of others, that it is like the muzzle of a Lyon; and of others, that it is Cain with a bundle of thorns on his back: therefore, to say Heaven is unalterable, because that in the Moon, or other Cœlestial bodies, no such alterations are seen, as discover themselves on Earth, is a bad illation, and concludeth nothing.

SAGR. And there is another odd kind of scruple in this Argument of *Simplicius*; running in my mind, which I would gladly have answered; therefore I demand of him, whether the Earth before the Mediterranean inundation was generable and corruptible, or else began then so to be?

SIMPL. It was doubtless generable and corruptible also before that time; but that was so vast a mutation, that it might have been observed as far as the Moon.

SAGR. Go to; if the Earth was generable and corruptible before that Inundation, why may not the Moon be so likewise without such a change? Or why should that be necessary in the Moon, which importeth nothing on Earth?

SALV. It is a shrewd question: But I am doubtfull that *Simplicius* a little altereth the Text of *Aristotle*, and the other *Peripateticks*, who say, they hold the Heavens unalterable, for that they see therein no one star generate or corrupt, which is probably a less part of Heaven, than a City is of the Earth, and yet innumerable of these have been destroyed, so as that no mark of them hath remain'd.

SAGR.

SAGR. I verily believed otherwise, and conceited that *Simplicius* dissembled this exposition of the Text; that he might not charge his Master and Consecrators, with a notion more absurd than the former. And what a folly it is to say the Cœlestial part is unalterable, because no stars do generate or corrupt therein? What then? hath any one seen a Terrestrial Globe corrupt, and another regenerate in its place? And yet is it not on all hands granted by Philosophers, that there are very few stars in Heaven less than the Earth, but very many that are much bigger? So that for a star in Heaven to corrupt, would be no less than if the whole Terrestrial Globe should be destroy'd. Therefore, if for the true proof of generation and corruption in the Universe, it be necessary that so vast bodies as a star, must corrupt and regenerate, you may satisfy your self and cease your opinion; for I assure you, that you shall never see the Terrestrial Globe or any other integral body of the World, to corrupt or decay so, that having been beheld by us for so many years past, they should so dissolve, as not to leave any footstep of them.

It is no less impossible for a star to corrupt, than for the whole Terrestrial Globe.

SALV. But to give *Simplicius* yet fuller satisfaction, and to reclaim him, if possible, from his error; I affirm, that we have in our age new accidents and observations, and such, that I question not in the least, but if *Aristotle* were now alive, they would make him change his opinion; which may be easily collected from the very manner of his discoursing: For when he writeth that he esteemeth the Heavens inalterable, &c. because no new thing was seen to be begot therein, or any old to be dissolved, he seems implicitly to hint unto us, that when he should see any such accident, he would hold the contrary; and confront, as indeed it is meet, sensible experiments to natural reason: for had he not made any reckoning of the senses, he would not then from the not seeing of any sensible mutation, have argued immutability.

Aristotle would change his opinion, did he see the novelties of our age.

SIMPL. *Aristotle* deduceth his principal Argument *à priori*, shewing the necessity of the inalterability of Heaven by natural, manifest and clear principles; and then stablisheth the same *à posteriori*, by sense, and the traditions of the antients.

SALV. This you speak of is the Method he hath observed in delivering his Doctrine, but I do not bethink it yet to be that wherewith he invented it; for I do believe for certain, that he first procured by help of the senses, such experiments and observations as he could, to assure him as much as it was possible, of the conclusion, and that he afterwards sought out the means how to demonstrate it: For this is the usual course in demonstrative Sciences, and the reason thereof is, because when the conclusion is true, by help of resolute Method, one may hit upon some proposition before demonstrated, or come to some principle known

The certainty of the conclusion helpeth by a resolute method to find the demonstration.

per

ier se-
made
since
he di-
had it
hange
loon;
would
hat e-
use to

bon, I
t such
lonely
clear,
her we
or any
eleno-
e hath
figura-
be say-
s, that
in with
is un-
ies, no
s a bad

Argu-
gladly
Earth
orrupti-

lso be-
t might

uptible
to like-
necessary

it Sim-
er Peri-
or that
proba-
nd yet
mark of

SAGR.

Pythagoras offered
an Hecatomb for
a Geometrical de-
monstration which
he found.

per se; but if the conclusion be false, a man may proceed in *in-
finitum*, and never meet with any truth already known; but ve-
ry oft he shall meet with some impossibility or manifest absurd-
ty. Nor need you question but that *Pythagoras* along time be-
fore he found the demonstration for which he offered the Heca-
tomb, had been certain, that the square of the side subtending
the right angle in a rectangle triangle, was equal to the square of
the other two sides: and the certainty of the conclusion condu-
ced not a little to the investigating of the demonstration, un-
derstanding me alwayes to mean in demonstrative Sciences. But
what ever was the method of *Aristotle*, and whether his arguing *a
priori* preceded sense *a posteriori*, or the contrary; it sufficeth that
the same *Aristotle* preferreth (as hath been oft said) sensible ex-
periments before all discourses; besides, as to the Arguments *a
priori* their force hath been already examined. Now returning
to my purposed matter, I say, that the things in our times dis-
covered in the Heavens, are, and have been such, that they may
give absolute satisfaction to all Philosophers; forasmuch as in
the particular bodies, and in the universal expansion of Heaven,
there have been, and are continually, seen just such accidents as
we call generations and corruptions, being that excellent A-
stronomers have observed many Comets generated and dissolved
in parts higher than the Lunar Orb, besides the two new Stars,

New Stars disco-
vered in Heaven.
Spots generate and
dissolve in the face
of the Sun.

Solar Spots are
bigger than all A-
frica and Astrick.

Anno 1572, and *Anno 1604*, without contradiction much higher
than all the Planets; and in the face of the Sun it self, by help
of the Telescope, certain dense and obscure substances, in sem-
blance very like to the fogs about the Earth, are seen to be
produced and dissolved; and many of these are so vast, that
they far exceed not only the Mediterranean Streight, but all
Africa and *Asia* also. Now if *Aristotle* had seen these things,
what think you he would have said, and done *Simplicius*?

Astronomers con-
futed by Anti-Ty-
cho.

SIMPL. I know not what *Aristotle* would have done or said,
that was the great Master of all the Sciences, but yet I know in
part, what his Sectators do and say, and ought to do and say,
unlesse they would deprive themselves of their guide, leader, and
Prince in Philosophy. As to the Comets, are not those Modern
Astronomers, who would make them Cœlestial, convinced by
the **Anti-Tycho*, yea, and overcome with their own weapons, I
mean by way of Parallaxes and Calculations, every way tryed,
concluding at the last in favour of *Aristotle*, that they are all
Elementary? And this being overthrown, which was as it were
their foundation, have these Novellists any thing more where-
with to maintain their assertion?

SALV. Hold a little, good *Simplicius*, this modern Author,
what faith he to the new Stars, *Anno 1572*, and *1604*, and to
the

the Solar spots? for as to the Comets, I for my own particular little care to make them generated under or above the Moon; nor did I ever put much stresse on the loquacity of *Tycho*; nor am I hard to believe that their matter is Elementary, and that they may elevate (sublimate) themselves at their pleasure, without meeting with any obstacle from the impenetrability of the *Peripatetick* Heaven; which I hold to be far more thin, yielding, and subtil than our Air; and as to the calculations of the Parallaxes, first, the uncertainty whether Comets are subject to such accidents, and next, the inconstancy of the observations, upon which the computations are made, make me equally suspect both those opinions: and the rather, for that I see him you call *Anti-Tycho*, sometimes stretch to his purpose, or else reject those observations which interfere with his design.

Anti-Tycho wresteth Astronomical observations to his own purpose.

SIMPL. As to the new Stars, *Anti-Tycho* extricates himself finely in three or four words; saying, That those modern new Stars are no certain parts of the Cœlestial bodies, and that the adversaries, if they will prove alteration and generation in those superior bodies, must shew some mutations that have been made in the Stars described so many ages past; of which there is no doubt but that they be Cœlestial bodies, which they can never be able to do: Next, as to those matters which some affirm, to generate and dissipate in the face of the Sun, he makes no mention thereof; wherefore I conclude, that he believed them fictitious, or the illusions of the Tube; or at most, some petty effects caused by the Air, and in brief, any thing rather than matters Cœlestial.

SALV. But you, *Simplicius*, what answer could you give to the opposition of these importunate spots which are started up to disturb the Heavens, and more than that, the *Peripatetick* Philosophy? It cannot be but that you, who are so resolute a Champion of it, have found some reply or solution for the same, of which you ought not to deprive us.

SIMPL. I have heard sundry opinions about this particular. One saith: "They are Stars which in their proper Orbs, like as Venus and Mercury, revolve about the Sun, and in passing under it, represent themselves to us obscure; and for that they are many, they oft happen to aggregate their parts together, and afterwards seperate again. Others believe them to be aerial impressions; others, the illusions of the chrystals; and others, other things: But I incline to think, yea am verily persuaded, That they are an aggregate of many several opacous bodies, as it were casually concurrent among themselves. And therefore we often see, that in one of those spots one may number ten or more such small bodies, which are of irregu-

Sundry opinions touching the Solar spots.

lar

lar figures, and seem to us like flakes of snow, or flocks of
 wooll, or moaths flying : they vary site amongst themselves,
 and one while sever, another while meet, and most of all be-
 neath the Sun, about which, as about their Centre, they con-
 tinually move. But yet, must we not therefore grant, that
 they are generated or dissolved; but that at sometimes they are
 hid behind the body of the Sun, and at other times, though
 remote from it, yet are they not seen for the vicinity of the
 immeasurable light of the Sun; in regard that in the eccentric
 Orb of the Sun, there is constituted, as it were, an Onion, com-
 posed of many folds one within another, each of which, being
 studded with certain small spots, doth move; and albeit their
 motion at first seemeth inconstant and irregular, yet neverthe-
 lesse, it is said at last, to be observed that the very same spots,
 as before, do within a determinate time return again. This
 seemeth to me the fittest answer that hath been found to assigne
 a reason of that same appearance, and withal to maintain the
 incorruptability and ingenerability of the Heavens; and if this
 doth not suffice; there wants not more elevated wits, which will
 give you others, more convincing.

* The Original
 saith [*tempesta si
 move*] which the
 Latine Translati-
 on, (mistaking
Tempesta, a word
 in Heraldry, for
Tempestate,) ren-
 dereth [*incitata
 movetur*] which
 signifieth a violent
 transportment, as
 in a storm, that of
 a Ship.

In natural Sci-
 ences, the art of
 Oratory is of no
 force.

SALV. If this of which we dispute, were some point of Law,
 or other part of the Studies called *Humanity*; wherein there is
 neither truth nor falshood, if we will give sufficient credit to
 the acutenesse of the wit, readinesse of answers, and the gene-
 ral practice of Writers; then he who most aboundeth in these,
 makes his reason more probable and plausible; but in Natural
 Sciences, the conclusions of which are true and necessary, and
 wherewith the judgment of men hath nothing to do, one is to
 be more cautious how he goeth about to maintain any thing that
 is false; for a man but of an ordinary wit, if it be his good for-
 tune to be of the right side, may lay a thousand *Demosthenes* and
 a thousand *Aristotles* at his feet. Therefore reject those hopes
 and conceits, wherewith you flatter your self, that there can be
 any men so much more learned, read, and versed in Authors,
 than we, that in despite of nature, they should be able to
 make that become true, which is false. And seeing that of all
 the opinions that have been hitherto alledged touching the es-
 sence of these Solar spots, this instanced in by you, is in your
 judgment the truest; it followeth (if this be so) that all the rest
 are false; and to deliver you from this also, which doubtlesse is a
 most false *Chimera*, over-passing infinite other improbabilities
 that are therein, I shall propose against it onely two experiments;
 one is, that many of those spots are seen to arise in the midst of
 the Solar ring, and many likewise to dissolve and vanish at a great
 distance from the circumference of the Sun; a necessary Argu-
 ment

An Argument
 that necessarily
 proveth the Solar
 spots to generate
 and dissolve.

ment that they generate and dissolve; for if without generating or corrupting, they should appear there by onely local motion, they would all be seen to enter, and pass out by the extreme circumference. The other observation to such as are not situate in the lowest degree of ignorance in Perspective, by the mutation of the appearing figures, and by the apparent mutations of the velocity of motion is necessarily concluding, that the spots are contiguous to the body of the Sun, and that touching its superficies, they move either with it or upon it, and that they in no wise move in circles remote from the same. The motion proves it, which towards the circumference of the Solar Circle, appeareth very slow, and towards the midst, more swift; the figures of the spots confirmeth it, which towards the circumference appear exceeding narrow in comparison of that which they seem to be in the parts nearer the middle; and this because in the midst they are seen in their full luster, and as they truly be; and towards the circumference by reason of the convexity of the globous superficies, they seem more compress'd: And both these diminutions of figure and motion, to such as know how to observe and calculate them exactly, precisely answer to that which should appear, the spots being contiguous to the Sun, and differ irreconcilably from a motion in circles remote, though but for small intervalls from the body of the Sun; as hath been diffusely demonstrated by our * Friend, in his Letters about the Solar spots, to *Marcus Velserus*. It may be gathered from the same mutation of figure, that none of them are stars, or other bodies of spherical figure; for that amongst all figures the sphere never appeareth compress'd, nor can ever be represented but onely perfectly round; and thus in case any particular spot were a round body, as all the stars are held to be, the said roundness would as well appear in the midst of the Solar ring, as when the spot is near the extreme: whereas, its so great compression, and shewing its self so small towards the extreme, and contrariwise, spacious and large towards the middle, assureth us, that these spots are flat plates of small thickness or depth, in comparison of their length and breadth. Lastly, whereas you say that the spots after their determinate periods are observed to return to their former aspect, believe it not, *Simplicius*, for he that told you so, will deceive you; and that I speak the truth, you may observe them to be hid in the face of the Sun far from the circumference; nor hath your Observator told you a word of that compression, which necessarily argueth them to be contiguous to the Sun. That which he tells you of the return of the said spots, is nothing else but what is read in the forementioned Letters, namely, that some of them may sometimes so happen that are of so long a duration, that

A conclusory demonstration, that the spots are contiguous to the body of the Sun.

The motion of the spots towards the circumference of the Sun appears slow.

The figure of the spots appears narrow towards the circumference of the Sun's discus, &c. why.

Under this word Friend, as also that of Academick, &c. Common Friend, Galileus modestly conceals himself throughout these Dialogues.

The Solar spots are not spherical, but flat like thin plates.

they cannot be dissipated by one sole conversion about the Sun, which is accomplished in less than a moneth.

SIMPL. I, for my part, have not made either so long, or so exact observations, as to enable me to boast my self Master of the *Quod est* of this matter : but I will more accurately consider the same, and make tryal my self for my own satisfaction, whether I can reconcile that which experience shews us, with that which *Aristotle* teacheth us ; for it's a certain Maxim, that two Truths cannot be contrary to one another.

One cannot (saith Aristotle) speak confidently of Heaven, by reason of its great distance.

SALV. If you would reconcile that which sense sheweth you, with the solidier Doctrines of *Aristotle*, you will find no great difficulty in the undertaking ; and that so it is, doth not *Aristotle* say, that one cannot treat confidently of the things of Heaven, by reason of their great remoteness ?

SIMPL. He expressly saith so.

Aristotle prefers sense before ratiocination.

SALV. And doth he not likewise affirm, that we ought to prefer that which sense demonstrates, before all Arguments, though in appearance never so well grounded ? and saith he not this without the least doubt or hæsitatio ?

SIMPL. He doth so.

It's a doctrine more agreeing with Aristotle, to say the Heavens are alterable, than that which affirms them inalterable.

We may by help of the Telescope discourse better of celestial matters, than Aristotle himself.

SALV. Why then, the second of these propositions, which are both the doctrine of *Aristotle*, that saith, that sense is to take place of Logick, is a doctrine much more solid and undoubted, than that other which holdeth the Heavens to be unalterable ; and therefore you shall argue more *Aristotelically*, saying, the Heavens are alterable, for that so my sense telleth me, than if you should say, the Heavens are unalterable, for that Logick so perswaded *Aristotle*. Furthermore, we may discourse of Cœlestial matters much better than *Aristotle* ; because, he confessing the knowledg thereof to be difficult to him, by reason of their remoteness from the senses, he thereby acknowledgeth, that one to whom the senses can better represent the same, may philosophate upon them with more certainty. Now we by help of the Telescope, are brought thirty or forty times nearer to the Heavens, than ever *Aristotle* came ; so that we may discover in them an hundred things, which he could not see, and amongst the rest, these spots in the Sun, which were to him absolutely invisible ; therefore we may discourse of the Heavens and Sun, with more certainty than *Aristotle*.

SAGR. I see into the heart of *Simplicius*, and know that he is much moved at the strength of these so convincing Arguments ; but on the other side, when he considereth the great authority which *Aristotle* hath won with all men, and remembreth the great number of famous Interpreters, which have made it their business to explain his sense ; and seeth other Sciences, so necessary and profitable

profitable to the publick, to build a great part of their esteem and reputation on the credit of *Aristotle* he is much puzzled and perplexed : and methinks I hear him say, To whom then should we repair for the decision of our controversies, if *Aristotle* were removed from the chair ? What other Author should we follow in the Schools, Academies and Studies ? What Philosopher hath writ all the parts of Natural Philosophy, and that so methodically without omitting so much as one single conclusion ? Shall we then overthrow that Fabrick under which so many passengers find shelter ? Shall we destroy that *Asylum*, that *Prytanenm*, wherein so many Students meet with commodious harbour, where without exposing themselves to the injuries of the air, with the onely turning over of a few leaves, one may learn all the secrets of Nature ? Shall we dismantle that fort in which we are safe from all hostile assaults ? But I pitie him no more than I do that Gentleman who with great expence of time and treasure, and the help of many hundred artists, erects a very sumptuous Pallace, and afterwards beholds it ready to fall, by reason of the bad foundation : *him being extremely unwilling to see the Walls stript which are adorned with so many beautifull Pictures ; or to suffer the columns to fall, that uphold the stately Galleries ; or the gilded roofs, chimney-pieces, the freizes, the cornishes of marble, with so much cost erected, to be ruined ; goeth about with girders, props, shoars, butterasses, to prevent their subversion.*

The Declamation of Simplicius.

SALV. But alas, *Simplicius* as yet fears no such fall, and I would undertake to secure him from that mischief at a far less charge. There is no danger that so great a multitude of subtle and wise Philosophers, should suffer themselves to be *Hector'd* by one or two, who make a little blustering ; nay, they will rather, without ever turning the points of their pens against them, by their silence onely render them the object of universal scorn and contempt. It is a fond conceit for any one to think to introduce new Philosophy, by reproving this or that Author : it will be first necessary to new-mold the brains of men, and make them apt to distinguish truth from falshood. A thing which onely God can do. But from one discourse to another whither are we stray'd ? your memory must help to guide me into the way again.

Peripatetick Philosophy unchangeable.

SIMPL. I remember very well where we left. We were upon the answer of *Anti-Tycho*, to the objections against the immutability of the Heavens, among which you inserted this of the Solar spots, not spoke of by him ; and I believe you intended to examine his answer to the instance of the New Stars.

SALV. Now I remember the rest, and to proceed, Methinks there are some things in the answer of *Anti-Tycho*, worthy of reprehension. And first, if the two New Stars, which he can do no less than place in the uppermost parts of the Heavens, and which were of a long duration, but finally vanished, give him no obstruction in maintaining the inalterability of Heaven, in that they were not certain parts thereof, nor mutations made in the ancient Stars, why doth he set himself so vigorously and earnestly against the Comets, to banish them by all ways from the Cœlestial Regions? Was it not enough that he could say of them the same which he spoke of the New stars? to wit, that in regard they were no certain parts of Heaven, nor mutations made in any of the Stars; they could no wise prejudice either Heaven, or the Doctrine of *Aristotle*? Secondly, I am not very well satisfied of his meaning; when he saith that the alterations that should be granted to be made in the Stars, would be destructive to the prerogative of Heaven; namely, its incorruptibility, &c. and this, because the Stars are Cœlestial substances, as is manifest by the consent of every one; and yet is nothing troubled that the same alterations should be made* without the Stars in the rest of the Cœlestial expansion. Doth he think that Heaven is no Cœlestial substance? I, for my part, did believe that the Stars were called Cœlestial bodies, by reason that they were in Heaven; or for that they were made of the substance of Heaven; and yet I thought that Heaven was more Cœlestial than they; in like sort, as nothing can be said to be more Terrestrial, or more fiery than the Earth or Fire themselves. And again, in that he never made any mention of the Solar spots, which have been evidently demonstrated to be produced, and dissolved, and to be neer the Sun, and to turn either with, or about the same, I have reason to think that this Author probably did write more for others pleasure, than for his own satisfaction; and this I affirm, forasmuch as he having shewn himself to be skilful in the Mathematicks; it is impossible but that he should have been convinced by Demonstrations, that those substances are of necessity contiguous with the body of the Sun, and are so great generations and corruptions, that none comparable to them, ever happen in the Earth: And if such, so many, and so frequent be made in the very Globe of the Sun, which may with reason be held one of the noblest parts of Heaven, what should make us think that others may not happen in the other Orbs?

*Extra Scellas.

Generability and alteration is a greater perfection in the Worlds bodies than the contrary qualities.
*Impatible.

SAGR. I cannot without great admiration, nay more, denial of my understanding, hear it to be attributed to natural bodies, for a great honour and perfection that they are* impatible, immutable, inalterable, &c. And on the contrary, to hear it to be

be esteemed a great imperfection to be alterable, generable, mutable, &c. It is my opinion that the Earth is very noble and admirable, by reason of so many and so different alterations, mutations, generations, &c. which are incessantly made therein; and if without being subject to any alteration; it had been all one vast heap of sand, or a masse of *Jasper*, or that in the time of the Deluge, the waters freezing which covered it, it had continued an immense Globe of Christal, wherein nothing had ever grown, altered, or changed, I should have esteemed it a lump of no benefit to the World, full of idleness, and in a word superfluous, and as if it had never been in nature, and should make the same difference in it, as between a living and dead creature: The like I say of the Moon, *Jupiter*, and all the other Globes of the World. But the more I dive into the consideration of the vanity of popular discourses, the more empty and simple I find them. And what greater folly can there be imagined, than to call Jems, Silver and Gold pretious; and Earth and dirt vile? For do not these persons consider, that if there should be as great a scarcity of Earth, as there is of Jewels and pretious metals, there would be no Prince, but would gladly give a heap of Diamonds and Rubies, and many Wedges of Gold, to purchase onely so much Earth as should suffice to plant a Gessamine in a little pot, or to set therein a *China Orange*, that he might see it sprout, grow up, and bring forth so goodly leaves, so odiferous flowers, and so delicate fruit? It is therefore scarcity and plenty that make things esteemed and contempned by the vulgar; who will say that same is a most beautiful Diamond, for that it resemblenth a cleer water, and yet will not part with it for ten Tun of water: These men that so extol incorruptibility, inalterability, &c. speak thus I believe out of the great desire they have to live long, and for fear of death; not considering, that if men had been immortal, they should have had nothing to do in the World. These deserve to meet with a *Medusa's* head, that would transform them into Statues of *Dimond* and *Jasper*, that so they might become more perfect than they are.

SALV. And it may be such a *Metamorphosis* would not be altogether unprofitable to them; for I am of opinion that it is better not to discourse at all, than to argue erroneously.

SIMPL. There is not the least question to be made, but that the Earth is much more perfect, being as it is alterable, mutable, &c. than if it had been a masse of stone; yea although it were one entire Diamond, most hard and impassible. But look how much these qualifications enoble the Earth, they render the Heavenly bodies again on the other side so much the more imperfect; in which, such conditions would be superfluous; in regard that the

The Earth very noble, by reason of the many mutations made therein.

The Earth unprofitable and full of idleness, its alterations taken away

The Earth more noble than Gold and Jewels.

Scarcity and plenty enhance and debase the price of things.

Incorruptibility esteemed by the vulgar out of their fear of death.

The disparagers of corruptibility deserve to be turned into Statues.

The Celestial bodies designed to serve the Earth, need no more but motion and light.

Cele-

Cœlestial bodies, namely, the Sun, Moon, and the other Stars, which are ordained for no other use but to serve the Earth, need no other qualities for attaining of that end, save onely those of light and motion.

SAGR. How? Will you affirm that nature hath produced and designed so many vast perfect and noble Cœlestial bodies, impassible, immortal, and divine, to no other use but to serve the passible, frail, and mortal Earth? to serve that which you call the drosse of the World, and sink of all uncleannesse? To what purpose were the Cœlestial bodies made immortal, &c. to serve a frail, &c. Take away this subserviency to the Earth, and the innumerable multitude of Cœlestial bodies become wholly unuseful, and superfluous, since they neither have nor can have any mutual operation betwixt themselves; because they are all unalterable, immutable, impassible: For if, for Example, the Moon be impassible, what influence can the Sun or any other Star have upon her? it would doubtlesse have far lesse effect upon her, than that of one who would with his looks or imagination, signifie a piece of Gold. Moreover, it seemeth to me, that whilst the Cœlestial bodies concur to the generation and alteration of the Earth, they themselves are also of necessity alterable; for otherwise I cannot understand how the application of the Sun or Moon to the Earth, to effect production, should be any other than to lay a marble Statue by a Womans side, and from that conjunction to expect children.

Cœlestial bodies want an interchangeable operation upon each other.

Alterability, &c. are not in the whole Terrestrial Globe, but in some of its parts.

SIMPL. Corruptibility, alteration, mutation, &c. are not in the whole Terrestrial Globe, which as to its whole, is no lesse eternal than the Sun or Moon, but it is generable and corruptible as to its external parts; but yet it is also true that likewise in them generation and corruption are perpetual, and as such require the heavenly eternal operations; and therefore it is necessary that the Cœlestial bodies be eternal.

SAGR. All this is right; but if the corruptibility of the superficial parts of the Earth be nowise prejudicial to the eternity of its whole Globe, yea, if their being generable, corruptible, alterable, &c. gain them great ornament and perfection; why cannot, and ought not you to admit alteration, generation, &c. likewise in the external parts of the Cœlestial Globes, adding to them ornament, without taking from them perfection, or bereaving them of action; yea rather encreasing their effects, by granting not onely that they all operate on the Earth, but that they mutually operate upon each other, and the Earth also upon them all?

Cœlestial bodies alterable in their outward parts.

SIMPL. This cannot be, because the generations, mutations, &c. which we should suppose *v. g.* in the Moon; would be vain and uselesse, & *natura nihil frustra facit.*

SAGR.

SAGR. And why should they be vain and uselesse?

SIMPL. Because we cleerly see, and feel with our hands, that all generations, corruptions, &c. made in the Earth, are all either mediately or immediately directed to the use, convenience, and benefit of man; for the use of man are horses brought forth, for the feeding of horses, the Earth produceth grasse, and the Clouds water it; for the use and nourishment of man, herbs, corn, fruits, beasts, birds, fishes, are brought forth; and in sum, if we should one by one dilligently examine and resolve all these things, we should find the end to which they are all directed, to be the necessity, use, convenience, and delight of man. Now of what use could the generations which we suppose to be made in the Moon or other Planets, ever be to mankind? unlesse you should say that there were also men in the Moon, that might enjoy the benefit thereof; a conceit either fabulous or impious.

The generations & mutations happening in the Earth, are all for the good of Man.

SAGR. That in the Moon or other Planets, there are generated either herbs, or plants, or animals, like to ours, or that there are rains, winds, or thunders there, as about the Earth, I neither know, nor believe, and much lesse, that it is inhabited by men: but yet I understand not, because there are not generated things like to ours, that therefore it necessarily followeth, that no alteration is wrought therein, or that there may not be other things that change, generate, and dissolve, which are not onely different from ours, but exceedingly beyond our imagination, and in a word, not to be thought of by us. And if, as I am certain, that one born and brought up in a spacious Forrest, amongst beasts and birds, and that hath no knowledg at all of the Element of Water, could never come to imagine another World to be in Nature, different from the Earth, full of living creatures, which without legs or wings swiftly move, and not upon the surface onely, as beasts do upon the Earth, but in the very bowels thereof; and not onely move, but also stay themselves and cease to move at their pleasure, which birds cannot do in the air; and that moreover men live therein, and build Palaces and Cities, and have so great convenience in travailing, that without the least trouble, they can go with their Family, House, and whole Cities, to places far remote, like as I say, I am certain, such a person, though of never so piercing an imagination, could never fancy to himself Fishes, the Ocean, Ships, Fleets, Armado's at Sea; thus, and much more easily, may it happn, that in the Moon, remote from us by so great a space, and of a substance perchance very different from the Earth, there may be matters, and operations, not only wide off, but altogether beyond all our imaginations, as being such as have no resemblance to ours, and therefore wholly inexcogitable, in regard, that what we ima-

The Moon hath no generations of things, like as we have, nor is it inhabited by men.

In the Moon may be a generation of things different from ours.

He that had not heard of the Element of Water, could never fancy to himself Ships and Fishes.

tars,
need
se of
and
pas-
pas-
the
what
ve a
ie in-
nuse-
any
unal-
Moon
have
than
sife a
Coe-
f the
other
Moon
to lay
on to
not in
eter-
as to
m ge-
e the
that
uper-
ity of
alter-
can-
like-
ng to
ereca-
grant-
y mu-
them
tions,
e vain
AGR.

imagine to our selves, must necessarily be either a thing already seen, or a composition of things, or parts of things seen at another time; for such are the *Sphinxes*, *Sirenes*, *Chimara's*, *Centaur's*, &c.

There may be Substances in the Moon very different from ours.

SALV. I have very often let my fancy ruminate upon these speculations, and in the end, have thought that I had found some things that neither are nor can be in the Moon; but yet I have not found therein any of those which I believe are, and may be there, save onely in a very general acceptation, namely, things that adorn it by operating, moving and living; and perhaps in a way very different from ours; beholding and admiring the greatness and beauty of the World, and of its Maker and Ruler, and with continual *Encomiums* singing his prayes; and in summe (which is that which I intend) doing what sacred Writers so frequently affirm, to wit, all the creatures making it their perpetual employment to laud God.

SAGR. These are the things, which speaking in general terms, may be there; but I would gladly hear you instance in such as you believe neither are nor can be there; which perchance may be more particularly named.

SALV. Take notice *Sagredus* that this will be the third time that we have unawares by running from one thing to another, lost our principal subject; and if we continue these digressions, it will be long ere we come to a conclusion of our discourse; therefore I should judge it better to remit this, as also such other points, to be decided on a particular occasion.

SAGR. Since we are now got into the Moon, if you please, let us dispatch such things as concern her, that so we be not forced to such another tedious journey.

The First resemblance between the Moon and Earth; which is that of figure; is proved by the manner of being illuminated by the Sun.

The Second conformity is the Moons being opacous as the Earth.

SALV. It shall be as you would have it. And to begin with things more general, I believe that the Lunar Globe is far different from the Terrestrial, though in some things they agree. I will recount first their resemblances, and next their differences. The Moon is manifestly like to the Earth in figure, which undoubtedly is spherical, as may be necessarily concluded from the aspect of its surface, which is perfectly Orbicular, and the manner of its receiving the light of the Sun, from which, if its surface were flat, it would come to be all in one and the same time illuminated, and likewise again in another instant of time obscured, and not those parts first, which are situate towards the Sun, and the rest successively, so that in its opposition, and not till then, its whole apparent circumference is enlightned; which would happen quite contrary, if the visible surface were concave; namely, the illumination would begin from the parts opposite or averse to the Sun. Secondly she is as the Earth, in her self obscure and opacous, by which opacity it is enabled to receive, and reflect the light of the Sun;

Sun; which were it not so, it could not do. Thirdly, I hold its matter to be most dense and solid as the Earth is, which I clearly argue from the unevenness of its superficies in most places, by means of the many eminencies and cavities discovered therein by help of the *Telescope*: of which eminencies there are many all over it, directly resembling our most sharp and craggy mountains, of which you shall there perceive some extend and run in ledges of an hundred miles long; others are contracted into rounder forms; and there are also many craggy, solitary, steep and cliffy rocks. But that of which there are frequentest appearances, are certain Banks (I use this word, because I cannot think of another that better expresseth them) pretty high raised, which environ and inclose fields of several bignesses, and form sundry figures, but for the most part circular; many of which have in the midst a mount raised pretty high, and some few are replenished with a matter somewhat obscure, to wit, like to the great spots discerned by the bare eye; and these are of the greatest magnitude; the number moreover of those that are lesser and lesser is very great, and yet almost all circular. Fourthly, like as the surface of our *Globe* is distinguished into two principal parts, namely, into the Terrestrial and Aquatick: so in the Lunar surface we discern a great distinction of some great fields more resplendant, and some less: whose aspect makes me believe, that that of the Earth would seem very like it, beheld by any one from the Moon, or any other the like distance, to be illuminated by the Sun: and the surface of the sea would appear more obscure, and that of the Earth more bright. Fifthly, like as we from the Earth behold the Moon, one while all illuminated, another while half; sometimes more, sometimes less; sometimes horned, sometimes wholly invisibly; namely, when its just under the Sun beams; so that the parts which look towards the Earth are dark: Thus in every respect, one standing in the Moon would see the illumination of the Earths surface by the Sun, with the same periods to an hair, and under the same changes of figures. Sixthly, —

SAGR. Stay a little; *Salviatus*; That the illumination of the Earth, as to the several figures, would represent it self to a person placed in the Moon, like in all things to that which we discover in the Moon, I understand very well, but yet I cannot conceive how it shall appear to be done in the same period; seeing that that which the Suns illumination doth in the Lunar superficies in a month, it doth in the Terrestrial in twenty four hours.

SALV. Its true, the effect of the Sun about the illuminating these two bodies, and replenishing with its splendor their whole surfaces, is dispatch'd in the Earth in a Natural day, and in the Moon in a Month; but the variation of the figures in which the

G

illumi-

Thirdly, The matter of the Moon is dense and monstrous as the Earth.

Fourthly, The Moon is distinguished into two different parts for clarity and obscurity, as the Terrestrial Globe into Sea and Land. The surface of the Sea would seem at a distance more obscure than that of the Earth.

Fifthly, Mutation of figures in the Earth, like to those of the Moon, and made with the same periods.

illuminated parts of the Terrestrial superficies appear beheld from the Moon, depends not on this alone, but on the divers aspects which the Moon is still changing with the Sun; so that, if for instance, the Moon punctually followed the motion of the Sun, and stood, for example, always in a direct line between it and the Earth, in that aspect which we call Conjunction, it looking always to the same Hemisphere of the Earth which the Sun looks unto, she would behold the same all light: as on the contrary, if it should always stay in Opposition to the Sun, it would never behold the Earth, of which the dark part would be continually turn'd towards the Moon, and therefore invisible. But when the Moon is in Quadrature of the Sun, that half of the Terrestrial Hemisphere exposed to the sight of the Moon which is towards the Sun, is luminous; and the other towards the contrary is obscure: and therefore the illuminated part of the Earth would represent it self to the Moon in a semi-circular figure.

SAGR. I clearly perceive all this, and understand very well, that the Moon departing from its Opposition to the Sun, where it saw no part of the illumination of the Terrestrial superficies, and approaching day by day nearer the Sun, she begins by little and little to discover some part of the face of the illuminated Earth; and that which appeareth of it shall resemble a thin sickle, in regard the figure of the Earth is round: and the Moon thus acquiring by its motion day by day greater proximity to the Sun, successively discovers more and more of the Terrestrial Hemisphere enlightned, so that at the Quadrature there is just half of it visible, inasmuch that we may see the other part of her: continuing next to proceed towards the Conjunction, it successively discovers more and more of its surface to be illuminated, and in fine, at the time of Conjunction seeth the whole Hemisphere enlightned. And in short, I very well conceive, that what befalls the Inhabitants of the Earth, in beholding the changes of the Moon, would happen to him that from the Moon should observe the Earth; but in a contrary order, namely, that when the Moon is to us at her full, and in Opposition to the Sun, then the Earth would be in Conjunction with the Sun, and wholly obscure and invisible; on the contrary, that position which is to us a Conjunction of the Moon with the Sun, and for that cause a Moon silent and unseen, would be there an Opposition of the Earth to the Sun, and, to so speak, *Full Earth*, to wit, all enlightned. And lastly, look what part of the Lunar surface appears to us from time to time illuminated, so much of the Earth in the same time shall you behold from the Moon to be obscured: and look how much of the Moon is to us deprived of light, so much of the Earth is to the Moon illuminated. In one thing yet these mutual operations in my judgment seem to differ, and it is, that it being

being supposed, and not granted, that some one being placed in the Moon to observe the Earth, he would every day see the whole Terrestrial superficies, by means of the Moons going about the Earth in twenty four or twenty five hours; but we never see but half of the Moon, since it revolves not in it self, as it must do to be seen in every part of it.

SALV. So that this, befalls not contrarily, namely, that her revolving in her self, is the cause that we see not the other half of her, for so it would be necessary it should be, if she had the Epicycle. But what other difference have you behind, to exchange for this which you have named?

SAGR. Let me see; Well for the present I cannot think of any other.

SALV. And what if the Earth (as you have well noted) seeth no more than half the Moon, whereas from the Moon one may see all the Earth; and on the contrary, all the Earth seeth the Moon, and but onely half of it seeth the Earth? For the inhabitants, to so speak, of the superior Hemisphere of the Moon, which is to us invisible, are deprived of the sight of the Earth, and these haply are the *Antiethones*. But here I remember a particular accident, newly observed by our *Academician*, in the Moon, from which are gathered two necessary consequences; one is, that we see somewhat more than half of the Moon; and the other is, that the motion of the Moon hath exact concentricity with the Earth: and thus he finds the *Phænomenon* and observation. When the Moon hath a correspondence and natural sympathy with the Earth, towards which it hath its aspect in such a determinate part, it is necessary that the right line which conjoyns their centers, do passe ever by the same point of the Moons superficies; so that, who so shall from the center of the Earth behold the same, shall alwayes see the same *Discus* or Face of the Moon punctually determined by one and the same circumference; But if a man be placed upon the Terrestrial surface, the ray which from his eye passeth to the centre of the Lunar Globe, will not pass by the same point of its superficies, by which the line passeth that is drawn from the centre of the Earth to that of the Moon, save onely when it is vertical to him: but the Moon being placed in the East, or in the West, the point of incidence of the visual ray, is higher than that of the line which conjoyns the centres; and therefore the observer may discern some part of the Lunar Hemisphere towards the upper circumference, and alike part of the other is invisible: they are discernable and undiscernable, in respect of the Hemisphere beheld from the true centre of the Earth: and because the part of the Moons circumference, which is superiour in its rising, is nethermost in its setting; therefore the difference of the said superiour and inferi-

All the Earth seeth half onely of the Moon, & the half onely of the Moon seeth all the Earth.

From the Earth we see more than half the Lunar Globe.

our parts must needs be very observable; certain spots and other notable things in those parts, being one while discernable, and another while not. A like variation may also be observed towards the North and South extremities of the same *Discus* (or Surface) according as the Moons position is in one or the other Section of its Dragon; For, if it be North, some of its parts towards the North are hid, and some of those parts towards the South are discovered, and so on the contrary. Now that these consequences are really true, is verified by the *Telescope*, for there be in the Moon two remarkable spots, one of which, when the Moon is in the meridian, is situate to the Northwest, and the other is almost diametrically opposite unto it; and the first of these is visible even without the *Telescope*; but the other is not. That towards the Northwest is a reasonable great spot of oval figure, separated from the other great ones; the opposite one is lesse, and also severed from the biggest, and situate in a very cleer field; in both these we may manifestly discern the foresaid variations, and see them one after another; now neer the edge or limb of the Lunar *Discus*, and anon remote, with so great difference that the distance betwixt the Northwest and the circumference of the *Discus* is more than twice as great at one time, as at the other; and as to the second spot (because it is neerer to the circumference) such mutation importeth more, than twice so much in the former. Hence its manifest, that the Moon, as if it were drawn by a magnetick vertue, constantly beholds the Terrestrial Globe with one and the same aspect, never deviating from the same.

SAGR. Oh! when will there be an end put to the new observations and discoveries of this admirable Instrument?

SALV. If this succeed according to the progresse of other great inventions, it is to be hoped, that in proceſſe of time, one may arrive to the sight of things, to us at present not to be imagined.

Sixthly, The Earth and Moon interchangeably do illuminate.

But returning to our first discourse, I say for the sixth resemblance betwixt the Moon and Earth, that as the Moon for a great part of time, supplies the want of the Suns light, and makes the nights, by the reflection of its own, reasonable clear; so the Earth, in recompence, affordeth it when it stands in most need, by reflecting the Solar rayes, a very cleer illumination, and so much, in my opinion, greater than that which cometh from her to us, by how much the superficies of the Earth is greater than that of the Moon.

Light reflected from the Earth in to the Moon.

SAGR. Hold there, *Salviatus* hold there, and permit me the pleasure of relating to you, how at this first hint I have penetrated the cause of an accident, which I have a thousand times thought upon, but could never find out. You would say, that the imperfect light which is seen in the Moon, especially when it is horned,

comes

comes from the reflection of the light of the Sun on the Superficies of the Earth and Sea; and that light is more clear, by how much the horns are lesse, for then the luminous part of the Earth, beheld by the Moon, is greater, according to that which was a little before proved; to wit, that the luminous part of the Earth, exposed to the Moon, is alway as great as the obscure part of the Moon, that is visible to the Earth; whereupon, at such time as the Moon is sharp-forked, and consequently its tenebrous part great, great also is the illuminated part of the Earth beheld from the Moon, and its reflection of light so much the more potent.

SALV. This is exactly the same with what I was about to say. In a word, it is a great pleasure to speak with persons judicious and apprehensive, and the rather to me, for that whilst others converse and discourse touching Axiomatical truths, I have many times creeping into my brain such arduous Paradoxes, that though I have a thousand times rehearsed this which you at the very first, have of your self apprehended, yet could I never beat it into mens brains.

SIMPL. If you mean by your not being able to persuade them to it, that you could not make them understand the same, I much wonder thereat, and am very confident that if they did not understand it by your demonstration (your way of expression, being, in my judgment, very plain) they would very hardly have apprehended it upon the explication of any other man; but if you mean you have not persuaded them, so as to make them believe it, I wonder not, in the least, at this; for I confesse my self to be one of those who understand your discourses, but am not satisfied therewith; for there are in this, and some of the other six congruities, or resemblances, many difficulties, which I shall instance in, when you have gone through them all.

SALV. The desire I have to find out any truth, in the acquist whereof the objections of intelligent persons (such as your self) may much assist me, will cause me to be very brief in dispatching that which remains. For a seventh conformity, take their reciprocal responson as well to injuries, as favours; whereby the Moon, which very often in the height of its illumination, by the interposure of the Earth betwixt it and the Sun, is deprived of light, and eclipsed, doth by way of revenge; in like manner, interpose it self between the Earth and the Sun, and with its shadow obscureth the Earth; and although the revenge be not answerable to the injury, for that the Moon often continueth, and that for a reasonable long time, wholly immersed in the Earths shadow, but never was the Earth wholly, nor for any long time, eclipsed by the Moon; yet, neverthelesse, having respect to the small-

Seventhly, The Earth and Moon do mutually eclipse.

smallness of the body of this, in comparison to the magnitude of the other, it cannot be denied but that the *will* and as it were *valour* of this, is very great. Thus much for their congruities or resemblances. It should next follow that we discourse touching their disparity; but because *Simplicius* will favour us with his objections against the former, its necessary that we hear and examine them, before we proceed any farther.

SAGR. And the rather, because it is to be supposed that *Simplicius* will not any ways oppose the disparities, and incongruities betwixt the Earth and Moon, since that he accounts their substances extremely different.

SIMPL. Amongst the resemblances by you recited, in the parallel you make betwixt the Earth and Moon, I find that I can admit none confidently save onely the first, and two others; I grant the first, namely, the spherical figure; howbeit, even in this there is some kind of difference, for that I hold that of the Moon to be very smooth and even, as a looking-glasse, whereas, we find and feel this of the Earth to be extraordinary mountainous and rugged; but this belonging to the inequality of superficies, it shall be anon considered, in another of those Resemblances by you alledged; I shall therefore reserve what I have to say thereof, till I come to the consideration of that. Of what you affirm next, that the Moon seemeth, as you say in your second Resemblance, opacous and obscure in its self, like the Earth; I admit not any more than the first attribute of opacity, of which the Eclipses of the Sun assure me. For were the Moon transparent, the air in the total obscuration of the Sun, would not become so dusky, as at such a time it is, but by means of the transparency of the body of the Moon, a refracted light would passe through it, as we see it doth through the thickest clouds. But as to the obscurity, I believe not that the Moon is wholly deprived of light, as the Earth; nay, that clarity which is seen in the remainder of its *Discus*, over and above the small crescent enlightened by the Sun, I repute to be its proper and natural light, and not a reflection of the Earth, which I esteem unable, by reason of its asperity (cragginess) and obscurity, to reflect the raies of the Sun. In the third Parallel I assent unto you in one part, and dissent in another: I agree in judging the body of the Moon to be most solid and hard, like the Earth, yea much more; for if from *Aristotle* we receive that the Heavens are impenetrable, and the Stars the most dense parts of Heaven, it must necessarily follow, that they are most solid and most impenetrable.

SAGR. What excellent matter would the Heavens afford us for to make Pallaces of, if we could procure a substance so hard and so transparent?

SALV.

The second clarity of the Moon esteemed to be its native light. The Earth unable to reflect the Sun's raies. The substance of the Heavens impenetrable, according to Aristotle.

DIALOGUE. I.

55

SALV. Rather how improper, for being by its transparence, wholly invisible, a man would not be able without stumbling at the thresholds, and breaking his head against the Walls, to pass from room to room.

SAGR. This danger would not befall him, if it be true, as some *Peripateticks* say, that it is intangible: and if one cannot touch it, much less can it hurt him.

The substance of Heaven intangible.

SALV. This would not serve the turn, for though the matter of the Heavens cannot be toucht, as wanting tangible qualities: yet may it easily touch the elementary bodies; and to offend us it is as sufficient that it strike us, nay worse, than if we should strike it. But let us leave these *Pallaces*, or, to say better, these *Castles* in the air, and not interrupt *Simplicius*.

SIMPL. The question which you have so casually started, is one of the most difficulty that is disputed in Philosophy; and I have on that subject most excellent conceits of a very learned Doctor of *Padova*, but it is not now time to enter upon them. Therefore returning to our purpose, I say that the Moon, in my opinion, is much more solid than the *Earth*, but do not infer the same, as you do, from the cragginess and montuosity of its superficies; but rather from the contrary, namely, from its aptitude to receive (as we see it experimented in the hardest stones) a polish and lustre exceeding that of the smoothest glass, for such necessarily must its superficies be, to render it apt to make so lively reflection of the Sun's rays. And for those appearances which you mention, of Mountains, Cliffs, Hills, Valleys, &c. they are all illusions: and I have been present at certain publick disputes, where I have heard it strongly maintained against these introducers of novelties, that such appearances proceed from nothing else, but from the unequal distribution of the opacous and perspicuous parts, of which the Moon is inwardly and outwardly composed: as we see it often fall out in chrystal, amber, and many other precious stones of perfect lustre; in which by reason of the opacity of some parts, and the transparency of others, there doth appear several concavities and prominencies. In the fourth resemblance, I grant, that the superficies of Terrestrial Globe beheld from afar, would make two different appearances, namely, one more clear, the other more dark; but I believe that such diversity would succeed quite contrary to what you say; that is, I hold that the surface of the water would appear lucid, because that it is smooth and transparent; and that of the Earth would appear obscure, by reason of its opacity and scabrosity, ill accommodated for reflecting the light of the Sun. Concerning the fifth comparison, I grant it wholly, and am able, in case the Earth did shine as the Moon, to show the same to any one that should from thence above behold it, represented

The superficies of the Moon more sleek, than any Looking-glass.

The eminencies and cavities in the Moon are illusions of its opacous and perspicuous parts.

SALV.

sented by figures answerable to those which we see in the Moon: I comprehend also, how the period of its illumination and variation of figure, would be monthly, albeit the Sun revolves round about it in twenty four hours: and lastly, I do not scruple to admit, that the half onely of the Moon seeth all the Earth, and that all the Earth seeth but onely half of the Moon. For what remains, I repute it most false, that the Moon can receive light from the Earth, which is most obscure, opacous, and utterly unapt to reflect the Suns light, as the Moon doth reflect it to us: and as I have said, I hold that that light which we see in the remainder of the Moons face (the splendid crescents subducted) by the illumination, is the proper and natural light of the Moon, and no easie matter would induce me to believe otherwise. The seventh, touching the mutual Eclipses, may be also admitted; howbeit that is wont to be called the eclipse of the Sun, which you are pleased to phrase the eclipse of the Earth. And this is what I have at this time to say in opposition to your seven congruities or resemblances, to which objections, if you are minded to make any reply, I shall willingly hear you.

SALV. If I have well apprehended what you have answered, it seems to me, that there still remains in controversie between us, certain conditions, which I made common betwixt the Moon & Earth, and they are these; You esteem the Moon to be smooth and polisht, as a Looking-glass, and as such, able to reflect the Suns light; and contrarily, the Earth, by reason of its montuosity, unable to make such reflection: You yield the Moon to be solid and hard, and that you argue from its being smooth and polite, and not from its being montuous; and for its appearing montuous, you assign as the cause, that it consists of parts more and less opacous and perspicuous. And lastly, you esteem that secondary light, to be proper to the Moon, and not reflected from the Earth; howbeit you seem not to deny the sea, as being of a smooth surface, some kind of reflection. As to the convincing you of that error, that the reflection of the Moon is made, as it were, like that of a Looking-glass, I have small hope, whilst I see, that what hath been read in the *Saggiator* and in the *Solar Letters* of our *Common Friend*, hath profited nothing in your judgment, if haply you have attentively read what he hath there written on this subject.

SIMPL. I have perused the same so superficially, according to the small time of leasure allowed me from more solid studies; therefore, if you think you can, either by repeating some of those reasons, or by alledging others, resolve me these doubts, I will hearken to them attentively.

SALV. I will tell you what comes into my mind upon the instant,

* Il Saggiatore, &
Lettere Solari,
two Treatises of
Galileus.

DIALOGUE I.

57

instant, and its possible it may be a commixtion of my own conceits, and those which I have sometime read in the fore-said Books, by which I well remember, that I was then perfectly satisfied, although the conclusions, at first sight seem'd unto me strange Paradoxes. We enquire *Simplicius*, whether to the making a reflection of light, like that which we receive from the Moon, it be necessary that the superficies from whence the reflection commeth, be so smooth and polite, as the face of a Looking-Glasse; or whether a superficies not smooth or polisht; but rough and uneven, be more apt for such a purpose. Now supposing two reflections should come unto us, one more bright, the other lesse, from two superficies opposite unto us, I demand of you, which of the two superficies you think would represent it self to our sight, to be the clearest, and which the obscurest.

SIMPL. I am very confident, that that same, which most forcibly reflected the light upon me, would shew its self in its aspect the clearer, and the other darker.

SALV. Be pleased to take that Glasse which hangs on yonder Wall, and let us go out into the Court-yard. Come *Sagredus*. Now hang the glasse yonder, against that same Wall, on which the Sun shines, and now let us with-draw our selves into the shade. See yonder two superficies beaten by the Sun, namely, the Wall and the Glasse. Tell me now which appears clearest unto you, that of the Wall or that of the Glasse? Why do you not answer me?

It is proved as large that the Moons surface is sharp.

SAGR. I leave the reply to *Simplicius*, who made the question; but I, for my own part, am perswaded upon this small beginning of the experiment, that the Moon must be of a very unpolisht surface.

SALV. What say you *Simplicius*, if you were to depaint that Wall, and that Glasse fastened unto it, where would you use your darkest colours, in designing the Wall, or else in painting the Looking-Glasse.

SIMPL. Much the darker in depainting the Glasse.

SALV. Now if from the superficies, which represents it self more clear, there proceedeth a more powerful reflection of light, the Wall will more forcibly reflect the raies of the Sun, than the Glasse.

SIMPL. Very well, Sir, have you ever a better experiment than this? you have placed us where the Glasse doth not reverberate upon us; but come along with me a little this way; how, will you not stir?

SAGR. You perhaps seek the place of the reflection, which the Glasse maketh.

SIMPL. I do so.

H

SAGR

SAGR. Why look you, there it is upon the opposite Wall, just as big as the Glasse, and little lesse bright than if the Sun had directly shined upon it.

SIMPL. Come hither therefore, and see from hence the surface of the Glasse, and tell me whether you think it more obscure than that of the Wall.

SAGR. Look on it your self, for I have no mind at this time, to dazle my eyes; and I know very well, without seeing it, that it there appears as splendid and bright as the Sun it self, or little lesse.

SIMPL. What say you therefore, is the reflection of a Glasse lesse powerful than that of a Wall? I see, that in this opposite Wall, where the reflection of the other illuminated Wall comes, together with that of the Glasse, this of the Glasse is much clearer; and I see likewise, that, from this place where I stand, the glasse it self appears with much more lustre than the Wall.

SATV. You have prevented me with your subtlety; for I stood in need of this very observation to demonstrate what remains. You see then the difference which happens betwixt the two reflections made by the two superficieses of the Wall and Glasse, perceived in the self-same manner, by the rayes of the Sun; and you see, how the reflection which comes from the Wall, diffuseth it self towards all the parts opposite to it, but that of the Glasse goeth towards one part onely, not at all bigger than the Glasse it self: you see likewise, how the superficies of the Wall, beheld from what part soever, alwayes shews it self of one and the same cleernesse; and every way, much clearer than that of the Glasse, excepting only in that little place, on which the Glasses reflection reverberates, for from thence indeed the Glasse appears much more lucid than the Wall. By these so sensible, and palpable experiments, my thinks one may soon come to know, whether the reflection which the Moon sends upon us, proceed as from a Glasse, or else, as from a Wall, that is, from a smooth superficies, or a rugged.

SAGR. If I were in the Moon it self, I think I could not with my hands more plainly feel the unevennesse of its superficies, than I do now perceive it, by apprehending your discourse. The Moon beheld in any posture, in respect of the Sun and us, sheweth us its superficies, touch't by the Sun's rayes, alwayes equally clear; an effect, which answers to an hair that of the Wall, which beheld from what place soever, appeareth equally bright, and differeth from the Glasse, which from one place onely appeareth lucid, and from all others obscure. Moreover, the light which cometh to me, from the reflection of the Wall, is tollerable, and weak, in comparison of that of the Glasse, which is little
lesse

lesse forcible and offensive to the sight, than that primary and direct light of the Sun. And thus without trouble do we behold the face of the Moon; which were it as a Glasse, it appearing to us by reason of its vicinity, as big as the Sun it self, its splendor would be absolutely intollerable, and would seem as if we beheld another Sun.

SALV. Ascribe not, I beseech you *Sagredus*, more to my demonstration, than it produceth. I will oppose you with an instance, which I see not well how you can easily resolve. You insist upon it as a grand difference between the Moon and Glasse, that it emits its reflection towards all parts equally, as doth the Wall; whereas the Glasse casts it upon one onely determinate place; and from hence you conclude the Moon to be like to the Wall, and not to the Glasse: But I must tell you, that that same Glasse casts its reflection on one place onely, because its surface is flat, and the reflex rayes being to depart at angles equal to those of the rayes of incidence, it must follow that from a plane or flat superficies, they do depart unitedly towards the same place; but in regard that the superficies of the Moon is not plain, but spherical, and the incident rayes upon such a superficies, being to reflect themselves at angles equal to those of the incidence towards all parts, by means of the infinity of the inclinations which compose the spherical superficies, therefore the Moon may send forth its reflection every way; and there is no necessity for its repercussion upon one place onely, as that Glasse which is flat.

Flat Looking-glasses cast forth the reflection towards but one place, but the spherical every way.

SIMPL. This is one of the very same objections, which I intended to have made against him.

SAGR. If this be one, you had need have more of them; yet I tell you, that as to this first, it seems to me to make more against you, than for you.

SIMPL. You have pronounced as a thing manifest, that the reflection made by that Wall, is as cleer and lucid as that which the Moon sends forth, and I esteem it nothing in comparison thereto.

“For, in this businesse of the illumination, its requisite to respect, and to distinguish the *Sphere of Activity*; and who questions but the Cœlestial bodies have greater Spheres of activity, than these our elementary, frail, and mortal ones? and that Wall, finally, what else is it but a little obscure Earth, unapt to shine?”

The Sphere of Activity greater in the Cœlestial bodies than in Elementary.

SAGR. And here also I believe, that you very much deceive yourself. But I come to the first objection moved by *Salviatus*; and I consider, that to make a body appear unto us luminous, it sufficeth not that the rayes of the illuminating body fall upon it, but it is moreover requisite that the reflex rayes arrive to our eye; as is manifestly seen in the example of that Glasse; upon

which, without question, the illuminating rayes of the Sun do come; yet neverthelesse, it appears not to us bright and shining, unlesse we set our eye in that particular place, where the reflection arriveth. Now let us consider what would succeed, were the glasse of a spherical figure; for without doubt, we should find, that of the reflection made by the whole surface illuminated, that to be but a very small part, which arriveth to the eye of a particular beholder; by reason that that is but an inconsiderable particle of the whole spherical superficies, the inclination of which casts the ray to the particular place of the eye; whence the part of the spherical superficies, which shews it self shining to the eye, must needs be very small; all the rest being represented obscure. So that were the Moon smooth, as a Looking-glasse, a very small part would be seen by any particular eye to be illustrated by the Sun, although its whole Hemisphere were exposed to the Suns rayes; and the rest would appear to the eye of the beholder as not illuminated, and therefore invisible; and finally, the whole Moon would be likewise invisible, for so much as that particle, whence the reflection should come, by reason of its smallnesse and remotenesse, would be lost. And as it would be invisible to the eye, so would it not afford any light; for it is altogether impossible, that a bright body should take away our darknesse by its splendor; and we not to see it.

The Moon if it were smooth, like a spherical glasse, would be invisible.

SALV. Stay good *Sagredus*, for I see some emotions in the face and eyes of *Simplicius*, which are to me as indices that he is not either very apprehensive of, or satisfied with this which you, with admirable proof, and absolute truth have spoken. And yet I now call to mind, that I can by another experiment remove all scruple. I have seen above in a Chamber, a great spherical Looking-glasse; let us send for it hither, and whilest it is in bringing, let *Simplicius* return to consider, how great the clarity is which cometh to the Wall here, under the penthouse, from the reflection of the flat glasse.

SIMPL. I see it is little lesse shining, than if the Sun had directly beat upon it.

SALV. So indeed it is. Now tell me, if taking away that small flat glasse, we should put that great spherical one in the same place, what effect (think you) would its reflection have upon the same Wall?

SIMPL. I believe that it would eject upon it a far greater and more diffused light.

SALV. But if the illumination should be nothing, or so small, that you would scarce discern it, what would you say then?

SIMPL. When I have seen the effect, I will bethink my self of an answer.

SALV.

SALV. See here is the glasse, which I would have to be placed close to the other. But first let us go yonder towards the reflection of that flat one, and attentively observe its clarity; see how bright it is here where it shines, and how distinctly one may discern these small unevennesses in the Wall.

SIMPL. I have seen and very well observed the same, now place the other glasse by the side of the first.

SALV. See where it is. It was placed there as soon as you began to look upon the Walls small unevennesses, and you perceived it not, so great was the encrease of the light all over the rest of the Wall. Now take away the flat glasse. Behold now all reflection removed, though the great convex glasse still remaineth. Remove this also, and place it there again if you please, and you shall see no alteration of light in all the Wall. See here then demonstrated to sense, that the reflection of the Sun, made upon a spherical convex glasse, doth not sensibly illuminate the places neerer unto it. Now what say you to this experiment?

SIMPL. I am afraid that there may be some *Leigerdeman*, used in this affair; yet in beholding that glasse I see it dart forth a great splendor, which dazleth my eyes; and that which imports most of all, I see it from what place soever I look upon it; and I see it go changing situation upon the superficies of the glasse, which way soever I place my self to look upon it; a necessary argument, that the light is lively reflected towards every side, and consequently, as strongly upon all that Wall, as upon my eye.

SALV. Now you see how cautiously and reservedly you ought to proceed in lending your assent to that, which discourse alone representeth to you. There is no doubt but that this which you say, carrieth with it probability enough; yet you may see, how sensible experience proves the contrary.

SIMPL. How then doth this come to pass?

SALV. I will deliver you my thoughts thereof, but I cannot tell how you may be pleas'd therewith. And first, that lively splendor which you see upon the glasse, and which you think occupieth a good part thereof, is nothing near so great, nay is very exceeding small; but its liveliness occasioneth in your eye, (by means of the reflection made on the humidity of the extreame parts of the eye-brows, which distendeth upon the pupil) an adventitious irradiation, like to that blaze which we think we see about the flame of a candle placed at some distance; or if you will, you may resemble it to the adventitious splendor of a star, for if you should compare the small body *v. g.* of the *Canicula*, seen in the day time with the *Telescope*, when it is seen without such irradiation, with the same seen by night by the eye it self, you will doubtless comprehend that being irradiated, it appeareth above a thousand times

The small body of the stars fringed round about with rays, appeareth very much bigger than plain and naked, and in its native clarity.

n do
ning,
refle-
were
ould
nina-
e eye
afide-
ration
hence
ining
repre-
king-
eye to
re ex-
eye of
; and
much
tion of
ould be
it is al-
ay our
ions in
ces that
s which
spoken.
eriment
a great
hilest it
reat the
thouse,
had di-
at small
he same
pon the
tter and
or so
you say
my self
SALV.

times bigger than the naked and real body : and a like or greater augmentation doth the image of the Sun make, which you see in that glafs. I say greater, for that it is more lively than the star, as is manifest from our being able to behold the star with much less offence, than this reflection of the glafs. The reverberation therefore which is to disperse it self all over this wall, cometh from a small part of that glafs, and that which even now came from the whole flat glafs dispersed and restrain'd it self to a very small part of the said wall. What wonder is it then, that the first reflection very lively illuminates, and that this other is almost imperceptible?

SIMPL. I find my self more perplexed than ever, and there presents it self unto me the other difficulty, how it can be that that wall, being of a matter so obscure, and of a superficies so unpolish'd, should be able to dart from it greater light, than a glafs very smooth and polite.

SALV. Greater light it is not, but more universal; for as to the degree of brightness, you see that the reflection of that small flat glafs, where it beamed forth yonder under the shadow of the penthouse, illuminateth very much; and the rest of the wall which receiveth the reflection of the wall on which the glafs is placed, is not in any great measure illuminated, as was the small part on which the reflection of the glafs fell. And if you would understand the whole of this business, you must consider that the superficies of that wall's being rough, is the same as if it were composed of innumerable small superficies, disposed according to innumerable diversities of inclinations: amongst which it necessarily happens, that there are many disposed to send forth their reflex rays from them into such a place, many others into another: and in sum, there is not any place to which there comes not very many rays, reflected from very many small superficies, dispersed throughout the whole superficies of the rugged body, upon which the rays of the Sun fall. From which it necessarily followeth, That upon any, whatsoever, part of any superficies, opposed to that which receiveth the primary incident rays, there is produced reflex rays, and consequently illumination. There doth also follow thereupon, That the same body upon which the illuminating rays fall, beheld from whatsoever place, appeareth all illuminated and shining: and therefore the Moon, as being of a superficies rugged and not smooth, beameth forth the light of the Sun on every side, and to all beholders appeareth equally lucid. But if the surface of it, being spherical, were also smooth as a glafs, it would become wholly invisible; forasmuch as that small part, from which the image of the Sun should be reflected unto the eye of

The reflex light of uneven bodies, is more universal than that of the smooth, & why.

The Moon, if it were smooth and sleek, would be invisible.

of a particular person, by reason of its great distance would be invisible, as I have said before.

SIMPL. I am very apprehensive of your discourse; yet methinks I am able to resolve the same with very little trouble; and easily to maintain, that the Moon is rotund and polite; and that it reflects the Sun's light unto us in manner of a glass; nor therefore ought the image of the Sun to be seen in the middle of it, forasmuch as the species of the Sun it self admits not its small figure to be seen at so great a distance, but the light produced by the Sun may help us to conceive that it illuminateth the whole Lunar Body: a like effect we may see in a plate gilded and well polish'd, which touch'd by a luminous body, appeareth to him that beholds it at some distance to be all shining; and onely near at hand one may discover in the middle of it the small image of the luminous body.

SALV. Ingenuously confessing my dullness of apprehension, I must tell you, that I understand not any thing of this your discourse, save onely what concerns the gilt plate: and if you permit me to speak freely, I have a great conceit that you also understand not the same, but have learnt by heart those words written by some one out of a desire of contradiction, and to shew himself more intelligent than his adversary; but it must be to those, which to appear also more wise, applaud that which they do not understand, and entertain a greater conceit of persons, the less they are by them understood: and the writer himself may be one of those (of which there are many) who write what they do not understand, and consequently understand not what they write. Therefore, omitting the rest, I reply, as to the gilt plate, that if it be flat and not very big, it may appear at a distance very bright, whilst a great light beameth upon it, but yet it must be when the eye is in a determinate line, namely in that of the reflex rays: and it will appear the more shining, if it were v. g. of silver, by means of its being burnished, and apt through the great density of the metal, to receive a perfect polish. And though its superficies, being very well brightned, were not exactly plain, but should have various inclinations, yet then also would its splendor be seen many ways; namely, from as many places as the various reflections, made by the several superficies, do reach: for therefore are Diamonds ground to many sides, that so their pleasing lustre might be beheld from many places. But if the Plate were very big, though it should be all plain, yet would it not at a distance appear all over shining: and the better to express my self, Let us suppose a very large gilt plate exposed to the Sun, it will shew to an eye far distant, the image of the Sun, to occupy no more but a certain part of the said plate; to wit, that from whence the reflection of the incident solar

Some write what they understand not, and therefore understand not what they write.

Diamonds ground to divers sides, & why.

*Silver burnished
appears more ob-
scure, than the not
burnished, & whi-*

*Burnish'd Steel
beheld from one
plane appears very
brilht, and from
another, very ob-
scure.*

solar rays come : but it is true, that by the vivacity of the light, the said image will appear fringed about with many rays, and so will seem to occupie a far greater part of the plate, than really it doth. And to shew that this is true, when you have noted the particular place of the plate from whence the reflection cometh, and conceived likewise how great the shining place appeared to you, cover the greater part of that same space, leaving it only visible about the midst ; and all this shall not any whit diminish the apparent splendor to one that beholds it from afar ; but you shall see it largely dispers'd upon the cloth or other matter, wherewith you covered it. If therefore any one, by seeing from a good distance a small gilt plate to be all over shining, should imagine that the same would also even in a plate as broad as the Moon, he is no less deceived, than if he should believe the Moon to be no bigger than the bottom of a tub. If again the plate were turn'd into a spherical superficies, the reflection would be seen strong in but one sole particle of it ; but yet by reason of its liveliness, it will appear fringed about with many glittering rays : the rest of the Ball would appear according as it was burnished ; and this also onely then when it was not very much polished, for should it be perfectly brightned, it would appear obscure. An example of this we have dayly before our eyes in silver vessels, which whilst they are only boyl'd in the *Argol* and *Salt*, they are all as white as snow, and do not reflect any image ; but if they be in any part burnish'd, they become in that place presently obscure : and in them one may see the representation of any thing as in Looking-glasses. And that chan- to obscurity, proceeds from nothing else but the smoothing and plaining of a fine grain, which made the superficies of the silver rough, and yet such, as that it reflected the light into all parts, whereby it seemed from all parts equally illuminated : which small unevennesses, when they come to be exquisitely plaind by the burnish, so that the reflection of the rays of incidence are all directed unto one determinate place ; then, from that same place, the burnish'd part shall shew much more bright and shining than the rest which is onely whitened by boyling ; but from all other places it looks very obscure. And note, that the diversity of sights, of looking upon burnish'd superficies, occasioneth such difference in appearances, that to imitate and represent in picture, v. g. a polish'd Cuirace, one must couple black plains with white, one sideways to the other, in those parts of the arms where the light falleth equally.

S A G R: If therefore these great Philosophers would acquiesce in granting, that the Moon, *Venus* and the other Planets, were not of so bright and smooth a surface as a Looking-glass, but wanted some small matter of it, namely, were as a silver plate, onely boyled white,

white, but not burnished; would this yet suffice to the making of it visible, and apt for darting forth the light of the Sun?

SALV. It would suffice in part; but would not give a light so strong, as it doth being mountainous, and in sum, full of eminencies and great cavities. But these Philosophers will never yield it to be lesse polite than a glasse; but far more, if more it can be imagined; for they esteeming that to perfect bodies perfect figures are most futable; it is necessary, that the sphericity of those Cœlestial Globes be most exact; besides, that if they should grant me some inequality, though never so small, I would not scruple to take any other greater; for that such perfection consisting in indivisibles, an hair doth as much detract from its perfection as a mountain.

SAGR. Here I meet with two difficulties, one is to know the reason why the greater inequality of superficies maketh the stronger reflection of light; the other is, why these Peripatetick Gentlemen are for this exact figure.

SALV. I will answer to the first; and leave to *Simplicius* the care of making reply to the second. You must know therefore, that the same superficies happen to be by the same light more or less illuminated, according as the rayes of illumination fall upon them more or lesse obliquely; so that the greatest illumination is where the rayes are perpendicular. And see, how I will prove it to your sense. I bend this paper, so, that one part of it makes an angle upon the other: and exposing both these parts to the reflection of the light of that opposite Wall, you see how this side which receiveth the rayes obliquely, is lesse shining than this other, where the reflection falls at right angles; and observe, that as I by degrees receive the illumination more obliquely; it groweth weaker.

The more rough superficies make greater reflection of light, than the lesse rough. Perpendicular rays illuminate more than the oblique, and why.

SAGR. I see the effect, but comprehend not the cause.

SALV. If you thought upon it but a minute of an hour, you would find it; but that I may not waste the time, see a kind of demonstration thereof in *Fig. 7.*

SAGR. The bare sight of this Figure hath fully satisfied me, therefore proceed.

SIMPL. Pray you let me hear you out, for I am not of so quick an apprehension.

SALV. Fancie to your self, that all the parallel lines, which you see to depart from the terms A. B. are the rays which fall upon the line C. D. at right angles: then incline the said C. D. till it hangs as D. O. now do not you see that a great part of those rays which peirce C. D. pass by without touching D. O. If therefore D. O. be illuminated by fewer rays, it is very reasonable, that the light received by it be more weak. Let us return now to the Moon, which

The more oblique Rayes illuminate less, and why.

which being of a spherical figure, if its superficies were smooth, as this paper, the parts of its hemisphere illuminated by the Sun, which are towards its extremity, would receive much less light, than the middle parts; the rays falling upon them most obliquely, and upon these at right angles; whereupon at the time of full Moon, when we see almost its whole Hemisphere illuminated, the parts towards the midst, would shew themselves to us with more splendor, than those others towards the circumference: which is not so in effect. Now the face of the Moon being represented to me full of indifferent high mountains, do not you see how their tops and continue ridges, being elevated above the convexity of the perfect spherical superficies, come to be exposed to the view of the Sun, and accommodated to receive its rays much less obliquely, and consequently to appear as luminous as the rest?

SAGR. All this I well perceive: and if there are such mountains, its true, the Sun will dart upon them much more directly than it would do upon the inclination of a polite superficies: but it is also true, that betwixt those mountains all the valleys would become obscure, by reason of the vast shadows, which in that time would be cast from the mountains, whereas the parts towards the middle, though full of valleys and hills, by reason they have the Sun elevated, would appear without shadow, and therefore more lucid by far than the extreme parts, which are no less diffused with shadow than light, and yet we can perceive no such difference.

SIMPL. I was ruminating upon the like difficulty.

SALV. How much readier is *Simplicius* to apprehend the objections which favour the opinions of *Aristotle*, than their solutions? I have a kind of suspicion, that he strives also sometimes to dissemble them; and in the present case, he being of himself able to hit upon the doubt, which yet is very ingenious; I cannot believe but that he also was advised of the answer; wherefore I will attempt to wrest the same (as they say) out of his mouth. Therefore tell me, *Simplicius*, do you think there can be any shadow, where the rays of the Sun do shine?

SIMPL. I believe, nay I am certain that there cannot; for that it being the grand luminary, which with its rays driveth away darkness, it is impossible any tenebrosity should remain where it cometh; moreover, we have the definition, that *Tenebrae sunt privatio luminis*.

SALV. Therefore the Sun, beholding the Earth, Moon or other opacous body, never seeth any of its shady parts, it not having any other eyes to see with, save its rays, the conveyers of light; and consequently, one standing in the Sun would never see any thing of umbrage, forasmuch as his visive rays would ever

go

DIALOGUE. I.

67

go accompanied with those illuminating beams of the Sun.

SIMPL. This is true, without any contradiction.

SALV. But when the Moon is opposite to the Sun, what difference is there between the tract of the rayes of your sight, and that motion which the Suns rayes make?

SIMPL. Now I understand you; for you would say, that the rayes of the sight and those of the Sun, moving by the same lines, we cannot perceive any of the obscure valleys of the Moon. Be pleased to change this your opinion, that I have either simulation or dissimulation in me; for I protest unto you, as I am a Gentleman, that I did not guesse at this solution, nor should I have thought upon it, without your help, or without long study.

SAGR. The resolutions, which between you two have been alledged touching this last doubt, hath, to speak the truth, satisfied me also. But at the same time this consideration of the visible rayes accompanying the rayes of the Sun, hath begotten in me another scruple, about the other part, but I know not whether I can expresse it right, or no: for it but just now comming into my mind, I have not yet methodized it to my mind: but let us see if we can, all together, make it intelligible. There is no question, but that the parts towards the circumference of that polish't, but not burnish't Hemisphere, which is illuminated by the Sun, receiving the rayes obliquely, receive much fewer thereof, than the middlemost parts, which receive them directly. And its possible, that a tract or space of *v. g.* twenty degrees in breadth, and which is towards the extremity of the Hemisphere, may not receive more rays than another towards the middle parts, of but four degree broad: so that that doubtless will be much more obscure than this; and such it will appear to whoever shall behold them both in the face, or (as I may say) in their full magnitude. But if the eye of the beholder were constituted in such a place, that the breadth of the twenty degrees of the obscure space, appeared not to it longer than one of four degrees, placed in the midst of the Hemisphere, I hold it not impossible for it to appear to the said beholder equally clear and lucid with the other; because, finally, between two equal angles, to wit, of four degrees apiece, there come to the eye the reflections of two equal numbers of rayes: namely, those which are reflected from the middlemost space, four degrees in breadth, and those reflected from the other of twenty degrees, but seen by compression, under the quantity of four degrees: and such a situation shall the eye obtain, when it is placed between the said Hemisphere, and the body which illuminates it; for then the sight and rayes move in the same lines. It seemeth not impossible therefore, but that the Moon may be of a very equal superficies; and that neverthelesse, it may appear when it is at the full, no less

I 2

light

light in the extremities, than in the middle parts.

SALV. The doubt is ingenious and worthy of consideration; and as it but just now came into your mind unawares, so I will like wise answer with what first comes into my thoughts; and it may happily fall out, that by thinking more upon it, I may stumble upon a better reply. But before, that I labyrinth my self any farther, it would be necessary, that we assure our selves by some experiment, whether your objection prove in effect, what it seemeth to conclude in appearance; and therefore taking once more the same paper, and making it to incline, by bending a little part thereof upon the remainder, let us try whether exposing it to the Sun, so that the rayes of light fall upon the lesser part directly, and upon the other obliquely; this which receiveth the rayes directly appeareth more lucid; and see here by manifest experience, that it is notably more clear. Now if your objection be conclusive, it will follow, that stooping with our eye so, that in beholding the other greater part, less illuminated, in compression or foreshortning, it appear unto us no bigger than the other, more shining; and that consequently, it be not beheld at a greater angle than that; it will necessarily ensue, I say, that its light be encreased, so that it do seem to us as bright as the other. See how I behold, and look upon it so obliquely, that it appeareth to me narrower than the other; but yet, notwithstanding its obscurity, doth not to my perceiving, at all grow clearer. Try now if the same succeed to you.

SAGR. I have look't upon it, and though I have stooped with my eye, yet cannot I see the said superficies encrease in light or clarity; nay me thinks it rather grows more dusky.

SALV. We are hitherto confident of the invalidity of the objection; In the next place, as to the solution, I believe, that, by reason the Superficies of this paper is little lesse than smooth, the rayes are very few, which be reflected towards the point of incidence, in comparison of the multitude, which are reflected towards the opposite parts; and that of those few more and more are lost, the nearer the visive rayes approach to those lucid rayes of incidence; and because it is not the incident rayes, but those which are reflected to the eye, that make the object appear luminous; therefore, in stooping the eye, there is more lost than got, as you your self confesse to have seen in looking upon the obscurer part of the paper.

SAGR. I rest satisfied with this experiment and reason: It remains now, that *Simplicius* answer to my other question, and tell me what moves the *Peripateticks* to require this so exact rotundity in the Cœlestial bodies.

SIMPL. The Cœlestial bodies being ingenerable, inalterable, impassible,

passible, immortal, &c. they must needs be absolutely perfect; and their being absolute perfect, necessarily implies that there is in them all kinds of perfection; and consequently, that their figure be also perfect, that is to say, spherical; and absolutely and perfectly spherical, and not rough and irregular.

SALV. And this incorruptibility, from whence do you prove it?

SIMP. Immediately by its freedom from contraries, and mediately, by its simple circular motion.

SALV. So that, by what I gather from your discourse, in making the essence of the Cœlestial bodies to be incorruptible, inalterable, &c. there is no need of rotundity as a cause, or requisite; for if this should cause inalterability, we might at our pleasure make wood, wax, and other Elementary matters, incorruptible, by reducing them to a spherical figure.

SIMP. And is it not manifest that a ball of Wood will better and longer be preserved, than an oblong, or other angular figure, made of a like quantity of the same wood.

SALV. This is most certain; but yet it doth not of corruptible become incorruptible, but still remains corruptible, though of a much longer duration. Therefore you must note, that a thing corruptible, is capable of being more or lesse such, and we may properly say this is lesse corruptible than that; as for example, the Jasper, than the *Pietra Sirena*; but incorruptibility admits not of more, or lesse, so as that it may be said this is more incorruptible than that, if both be incorruptible and eternal. The diversity of figure therefore cannot operate: save onely in matters capable of more or lesse duration; but in the eternal, which cannot be other than equally eternal, the operation of figure ceaseth. And therefore, since the Cœlestial matter is not incorruptible by figure, but otherways no man needs to be so solicitous for this perfect sphericity; for if the matter be incorruptible, let it have what figure it will, it shall be alwayes such.

SALV. But I am considering another thing; and say; that if we should grant the spherical figure a faculty of conferring incorruptibility, all bodies of whatsoever figure, would be incorruptible; forasmuch as if the rotund body be incorruptible, corruptibility would then subsist in those parts which alter the perfect rotundity; as for instance, there is in a *Disc* a body perfectly round, and, as such, incorruptible; therefore it remaineth that those angles be corruptible which cover and hide the rotundity; so that the most that could happen, would be, that those angles, and (to so speak) excrescencies, would corrupt. But if we proceed to a more inward consideration, that in those parts also towards the angles, there are comprised other lesser balls of the same matter; and

Perfect sphericity why ascribed to Cœlestial bodies, by the Peripateticks.

The Figure is not the cause of incorruptibility, but of longer duration.

Corruptibility admits of more or lesse; so doth not incorruptibility.

The perfection of figure, operateth in corruptible bodies, but not in the eternal.

If the spherical figure conferreth eternicity, all bodies would be eternal.

and therefore they also, as being round, must be also incorruptible; and likewise in the remainders, which environ these eight lesser Spheres, a man may understand that there are others: so that in the end, resolving the whole *Dic* into innumerable balls, it must necessarily be granted incorruptible. And the same discourse and resolution may be made in all other figures.

SALV. Your method in making the conclusion, for if v. g. a round Chrystal were, by reason of its figure, incorruptible; namely, received from thence a faculty of resisting all internal and external alterations, we should not find, that the joyning to it other Chrystal; and reducing it v. g. into a Cube, would any whit alter it within, or without; so as that it would thereupon become lesse apt to resist the new ambient, made of the same matter, than it was to resist the other, of a matter different; and especially, if it be true, that corruption is generated by contraries, as *Aristotle* saith; and with what can you enclose that ball of Chrystal, that is lesse contrary to it, than Chrystal it self? But we are not aware how time flies away; and it will be too late before we come to an end of our dispute, if we should make so long discourses, upon every particular; besides our memories are so confounded in the multiplicity of notions, that I can very hardly recal to mind the Propositions, which I proposed in order to *Simplicius*, for our consideration.

SIMPL. I very well remember them: And as to this particular question of the montuosity of the Moon, there yet remains unanswered that which I have alledged, as the cause, (and which may very well serve for a solution) of that *Phænomenon*, saying, that it is an illusion proceeding from the parts of the Moon, being unequally opacous, and perspicuous.

SAGR. Even now, when *Simplicius* ascribed the apparent Protruberancies or unevennesses of the Moon (according to the opinion of a certain *Peripatetick* his friend) to the diversly opacous, and perspicuous parts of the said Moon, conformable to which the like illusions are seen in Chrystal, and Jems of divers kinds, I bethought my self of a matter much more commodious for the representing such effects; which is such, that I verily believe, that that Philosopher would give any price for it; and it is the mother of Pearl, which is wrought into divers figures, and though it be brought to an extreme evenness, yet it seemeth to the eye in several parts, so variously hollow and knotty, that we can scarce credit our feeling of their evenness.

SALV. This invention is truly ingenious; and that which hath not been done already, may be done in time to come; and if there have been produced other Jems, and Crystals, which have nothing to do with the illusions of the mother of Pearl, these may be

Mother of Pearl accommodated to imitate the apparent unevennesses of the Moons surface.

be produced also; in the mean time, that I may not prevent any one, I will suppress the answer which might be given, and onely for this time betake my self to satisfie the objections brought by *Simplicius*. I say therefore, that this reason of yours is too general, and as you apply it not to all the appearances one by one; which are seen in the Moon, and for which my self and others are induced to hold it mountainous, I believe you will not find any one that will be satisfied with such a doctrine; nor can I think, that either you, or the Author himself, find in it any greater quietude, than in any other thing wide from the purpose. Of the very many several appearances which are seen night by night in the course of Moon, you cannot imitate so much as one, by making a Ball at your choice, more or less opacous and perspicuous, and that is of a polite superficies; whereas on the contrary, one may make Balls of any solid matter whatsoever, that is not transparent, which onely with eminencies and cavities, and by receiving the illumination several ways, shall represent the same appearances and mutations to an hair, which from hour to hour are discovered in the Moon. In them you shall see the ledges of Hills exposed to the Suns light, to be very shining, and after them the projections of their shadows very obscure; you shall see them greater and less, according as the said eminencies shall be more or less distant from the confines which distinguish the parts of the Moon illuminated, from the obscure; you shall see the same term and confine, not equally distended, as it would be if the Ball were polish'd, but craggie and rugged. You shall see beyond the same term, in the dark parts of the Moon many bright prominencies, and distinct from the rest of the illuminations: you shall see the shadows aforesaid, according as the illumination gradually riseth, to diminish by degrees, till they wholly disappear; nor are there any of them to be seen when the whole Hemisphere is enlightened. Again on the contrary, in the lights passage towards the other Hemisphere of the Moon, you shall again observe the same eminencies that were marked, and you shall see the projections of their shadows to be made a contrary way, and to decrease by degrees: of which things, once more I say, you cannot shew me so much as one in yours that are opacous and perspicuous.

SAGRE. One of them certainly he may imitate, namely, that of the Full-Moon, when by reason of its being all illuminated, there is not to be seen either shadow, or other thing, which receiveth any alteration from its eminencies and cavities. But I beseech you, *Salviatus*, let us spend no more time on this Argument, for a person that hath had but the patience to make observation of but one or two Lunations, and is not satisfied with this most sensible truth, may well be adjudged void of all judgment; and upon such

The apparent unevennesses of the Moon cannot be imitated by way of more and less opacous & perspicuity.
The various aspects of the Moon, imitable with any opacous matter.

Various appearances from which the Moons mountainousness is argued.

such why should we throw away our time and breath in vain?

SIMPL. I must confess I have not made the observations, for that I never had so much curiosity, or the Instruments proper for the business; but I will not fail to do it. In the mean time, we may leave this question in suspense, and pass to that point which follows, producing the motives inducing you to think that the Earth may reflect the light of the Sun no less forceably than the Moon, for it seems to me so obscure and opacous, that I judg such an effect altogether impossible.

SALV. The cause for which you repute the Earth unapt for illumination, may rather evince the contrary: And would it not be strange, *Simplicius*, if I should apprehend your discourses better than you your self?

SIMPL. Whether I argue well or ill, it may be, that you may better understand the same than I; but be it ill or well that I discourse, I shall never believe that you can penetrate what I mean better than I my self.

SALV. Well, I will make you believe the same presently. Tell me a little, when the Moon is near the Full, so that it may be seen by day, and also at midnight, at what do you think it more splendid, by day or by night?

The Moon appears brighter by night than by day.

The Moon beheld in the day time, is like to a little cloud.

SIMPL. By night, without all comparison. And methinks the Moon resembleth that pillar of Clouds and pillar of Fire, which guided the *Israelites*; which at the presence of the Sun, appeared like a Cloud, but in the night was very glorious. Thus I have by day observed the Moon amidst certain small Clouds, just as if one of them had been coloured white, but by night it shines with much splendor.

SALV. So that if you had never happened to see the Moon, save onely in the day time, you would not have thought it more shining than one of those Clouds.

SIMPL. I verily believe I should not.

SALV. Tell me now, do you believe that the Moon is really more shining in the night than day, or that by some accident it seemeth so?

SIMPL. I am of opinion, that it resplends in it self as much in the day as night, but that its light appears greater by night, because we behold it in the dark mantle of Heaven; and in the day time, the whole Atmosphere being very clear, so that the little exceedeth it in lustre, she seems to us much less bright.

SALV. Now tell me, have you ever at midnight seen the Terrestrial Globe illuminated by the Sun?

SIMPL. This seemeth to me a question not to be ask'd, unless in jest, or of some person known to be altogether void of sense.

SALV. No, no; I esteem you to be a very rational man, and do

do ask the question seriously; and therefore answer me: and if afterwards you shall think that I speak impertinently, I will be content to be the senseless man: for he is much more a fool who interrogates simply, than he to whom the question is put.

SIMPL. If then you do not think me altogether simple, take it for granted that I have answered you already, and said, that it is impossible, that one that is upon the Earth, as we are, should see by night that part of the Earth where it is day, namely, that is illuminated by the Sun.

SALV. Therefore you have never seen the Earth enlightned, save onely by day; but you see the Moon to shine also in the dead of night. And this is the cause, *Simplicius*, which makes you believe that the Earth doth not shine like the Moon; but if you could see the Earth illuminated, whilst you were in some dark place, like our night, you would see it shine brighter than the Moon. Now if you desire that the comparison may proceed well, you must compare the light of the Earth, with that of the Moon seen in the day time, and not with the same by night: for it is not in our power to see the Earth illuminated, save onely in the day. Is it not so?

SIMPL. So it ought to be.

SALV. And forasmuch as you your self have already confessed to have seen the Moon by day among some little white Clouds, and very nearly, as to its aspect, resembling one of them; you did thereby grant, that those Clouds, which yet are Elementary matters, are as apt to receive illumination, as the Moon, yea more, if you will but call to mind that you have sometimes seen some Clouds of vast greatness, and as perfect white as the Snow; and there is no question, but that if such a Cloud could be continued so luminous in the deep of night, it would illuminate the places near about it, more than an hundred Moons. If therefore we were assured that the Earth is illuminated by the Sun, like one of those Clouds, it would be undubitable, but that it would be no less shining than the Moon. But of this there is no question to be made, in regard we see those very Clouds in the absence of the Sun, to remain by night, as obscure as the Earth: and that which is more, there is not any one of us, but hath seen many times some such Clouds low, and far off, and questioned whether they were Clouds or Mountains: an evident sign that the Mountains are no less luminous than those Clouds.

SAGR. But what needs more discourse? See yonder the Moon is risen, and more than half of it illuminated; see there that wall, on which the Sun shineth; retire a little this way, so that you see the Moon sideways with the wall: look now; which of them shews more lucid? Do not you see, that if there is any advantage;

K

the

Clouds are no less apt than the Moon to be illuminated by the Sun.

A wall illuminated by the Sun, compared to the Moon shineth no less than it.

The third reflection of a Wall illuminates more than the first of the Moon.

the wall hath it? The Sun shineth on that wall; from thence it is reverberated upon the wall of the Hall, from thence it's reflected upon that chamber, so that it falls on it at the third reflection: and I am very certain, that there is in that place more light, than if the Moons light had directly fallen upon it.

SIMPL. But this I cannot believe; for the illumination of the Moon, especially when it is at the full, is very great.

The light of the Moon weaker than that of the twilight.

SAGR. It seemeth great by reason of the circumjacent dark places; but absolutely it is not much, and is less than that of the twilight half an hour after the Sun is set; which is manifest, because you see not the shadows of the bodies illuminated by the Moon till then; to begin to be distinguished on the Earth. Whether, again, that third reflection upon that chamber, illuminates more than the first of the Moon, may be known by going thither, and reading a Book, and afterwards standing there in the night by the Moons light, which will shew by which of them lights one may read more or less plainly, but I believe without further tryal, that one should see less distinctly by this later.

SALV. Now, *Simplicius*, (if haply you be satisfied) you may conceive, as you your self know very well, that the Earth doth shine no less than the Moon; and the only reminding you of some things, which you knew of your self, and learn'd not of me, hath assured you thereof: for I taught you not that the Moon shews lighter by night than by day, but you understood it of your self; as also you could tell me that a little Cloud appeareth as lucid as the Moon: you knew also, that the illumination of the Earth cannot be seen by night; and in a word, you knew all this, without knowing that you knew it. So that you have no reason to be scrupulous of granting, that the dark part of the Earth may illuminate the dark part of the Moon, with no less a light than that wherewith the Moon illuminates the obscurities of the night, yea rather so much the greater, inasmuch as the Earth is forty times bigger than the Moon.

SIMPL. I must confess that I did believe, that that secondary light had been the natural light of the Moon.

Luminous bodies appear the brighter in an obscurer ambient.

SALV. And this also you know of your self, and perceive not that you know it. Tell me, do not you know without teaching, that the Moon shews it self more bright by night than by day, in respect of the obscurity of the space of the ambient? and consequently, do you not know *in genere*, that every bright body shews the clearer, by how much the ambient is obscurer?

SIMPL. This I know very well.

SALV. When the Moon is horned, and that secondary light seemeth to you very bright, is it not ever nigh the Sun, and consequently, in the light of the *crepusculum*, (twilight?)

SIMPL.

SIMPL. It is so; and I have oftentimes wish'd that the Air would grow thicker, that I might be able to see that same light more plainly; but it ever disappeared before dark night.

SALV. You know then very certainly, that in the depth of night, that light would be more conspicuous.

SIMPL. I do so; and also more than that, if one could but take away the great light of the crescent illuminated by the Sun, the presence of which much obscureth the other lesser.

SALV. Why, doth it not sometimes come to pass, that one may in a very dark night see the whole face of the Moon, without being at all illuminated by the Sun?

SIMPL. I know not whether this ever happeneth, save only in the total Eclipses of the Moon.

SALV. Why, at that time this its light would appear very clear, being in a most obscure *medium*, and not darkned by the clarity of the luminous crescents: but in that position, how light did it appear to you?

SIMPL. I have sometimes seen it of the colour of brasse, and a little whitish; but at other times it hath been so obscure, that I have wholly lost the sight of it.

SALV. How then can that light be so natural, which you see so clear in the close of the twilight, notwithstanding the impediment of the great and contiguous splendor of the crescents; and which again, in the more obscure time of night, all other light removed, appears not at all?

SIMPL. I have heard of some that believed that same light to be participated to these crescents from the other Stars, and in particular from *Venus*, the Moons neighbour.

SALV. And this likewise is a vanity; because in the time of its total obscuration, it ought to appear more shining than ever; for you cannot say, that the shadow of the Earth intercepts the sight of *Venus*, or the other Stars. But to say true, it is not at that instant wholly deprived thereof, for that the Terrestrial Hemisphere, which in that time looketh towards the Moon, is that where it is night, that is, an intire privation of the light of the Sun. And if you but diligently observe, you will very sensibly perceive, that like as the Moon, when it is sharp-horned, doth give very little light to the Earth; and according as in her the parts illuminated by the Suns light do encrease: so likewise the splendor to our seeming encrease, which from her is reflected towards us; thus the Moon, whilst it is sharp-forked, and that by being between the Sun and the Earth, it discovereth a very great part of the Terrestrial Hemisphere illuminated, appeareth very clear: and departing from the Sun, and passing towards the *Quadrature*, you may see the said light by degrees grow dim; and after the

**By the Moons two Quadratures you are to understand its first and last quarters, as Astrologers call them*

Quadrature, the same appears very weak, because it continually loseth more and more of the view of the luminous part of the Earth: and yet it should succeed quite contrary, if that light were its own, or communicated to it from the Stars; for then we should see it in the depth of night, and in so very dark an ambient.

*The secondary
light of the Moon
caused by the Sun,
according to some.*

SIMPL. Stay a little; for I just now remember, that I have read in a little modern tract, full of many novelties; "That this
"secondary light is not derived from the Stars, nor innate in the
"Moon, and least of all communicated by the Earth, but that it is
"received from the same illumination of the Sun, which, the substance of the Lunar Globe being somewhat transparent, penetrateth thorow all its body; but more lively illuminateth the
"superficies of the Hemisphere exposed to the rays of the Sun: and its profundity imbuing, and (as I may say) swallowing that
"light, after the manner of a cloud or chrystal, transmits it; and renders it visibly lucid. And this (if I remember aright) he
"proveth by Authority, Experience and Reason; citing *Cleomedes*,
"Virellidus, Macrobius, and a certain other modern Author: and adding, That it is seen by experience to shine most in the days
"nearest the Conjunction, that is, when it is horned, and is chiefly
"brilghe about its limb. And he farther writes, That in the Solar
"Eclipses, when it is under the *Discus* of the Sun, it may be seen
"translucid, and more especially towards its utmost Circle. And
"in the next place, for Arguments, as I think, he saith, That it not
"being able to derive that light either from the Earth, or from the
"Stars, or from it self, it necessarily follows, that it cometh from
"the Sun. Besides that, if you do but grant this supposition, one
"may easily give convenient reasons for all the particulars that
"occur. For the reason why that secondary light shews more
"lively towards the outmost limb, is, the shortness of the space
"that the Sun's rays hath to penetrate, in regard that of the lines
"which pass through a circle, the greatest is that which passeth
"through the centre; and of the rest, those which are farthest from
"it, are always less than those that are nearer. From the same
"principle, he saith, may be shewn why the said light doth not
"much diminish. And lastly, by this way the cause is assigned
"whence it comes, that that same more shining circle about the
"utmost edge of the Moon, is seen at the time of the Solar Eclipse, in that part which lyeth just under the *Discus* of the Sun,
"but not in that which is beside the *Discus*: which happeneth
"because the rays of the Sun pass directly to our eye, through the
"parts of the Moon underneath: but as for the parts which are
"besides it, they fall besides the eye.

SALV. If this Philosopher had been the first Author of this opinion, I would not wonder that he should be so affectionate to it,

as to have received it for truth; but borrowing it from others, I cannot find any reason sufficient to excuse him for not perceiving its fallacies; and especially after he had heard the true cause of that effect, and had it in his power to satisfy himself by a thousand experiment, and manifest circumstances, that the same proceeded from the reflection of the Earth, and from nothing else: and the more this speculation makes something to be desired, in the judgment of this Author, and of all those who give no credit to it: so much the more doth their not having understood and remembred it, excuse those more recess Antients, who, I am very certain, did they now understand it, would without the least repugnance admit thereof. And if I may freely tell you what I think, I cannot believe but that this Modern doth in his heart believe it; but I rather think that the conceit he should not be the first Author thereof, did a little move him to endeavour to suppress it, or to disparage it at least amongst the simple, whose number we know to be very great; and many there are, who much more affect the numerous applauses of the people, than the approbation of a few not vulgar judgments.

SALV. Hold good *Salvatus*, for me thinks, I see that you go not the way to hit the true mark in this your discourse, for these that confound all propriety, know also how to make themselves Authors of others inventions, provided they be not so stale, and publick in the Schools and Market-places, as that they are more then notorious to every one.

SALV. Ha! well aimed; you blame me for roving from the point in hand; but what have you to do with Schools and Markets? Is it not all one, whether opinions and inventions be new to men, or the men new to them? If you contend about the esteem of the Founders of Sciences, which in all times do start up, you may make your self their inventor, even to the Alphabet it self, and so gain admiration amongst that illiterate rabble; and though in processe of time your craft should be perceived, that would but little prejudice your designe; for that others would succeed them in maintaining the number of your fautors; but let us return to prove to *Simplicius* the invalidity of the reasons of his modern Author, in which there are several falsities, inconsequencies, and incredible Paradoxes. And first, it is false that this secondary light is clearer about the utmost limb than in the middle parts, so as to form, as it were, a ring or circle more bright than the rest of its space or contence. True it is, indeed, that looking on the Moon at the time of twilight, at first sight there is the resemblance of such a circle, but by an illusion arising from the diversity of confines that bound the Moons *Discus*, which are confused by means of this secondary light; forasmuch as on the part

towards

* Tendon le preteal communc.

It is all one whether opinions be new to men, or men new to opinions.
* Contentare falsity rendered in the Latine Translation contentare.

The secondary light of the Moon appears in form of a Ring, that is to say, bright in the extreme circumference, and not in the midst, and why.

The way to observe the secondary light of the Moon.

towards the Sun it is bounded by the lucid horns of the Moon, and on the other part, its confining term is the obscure tract of the twilight; whose relation makes us think the candor of the Moons *Discus* to be so much the clearer; the which happens to be obfuscated in the opposite part, by the greater clarity of the crescents; but if this modern Author had essayed to make an interposition between the eye and the primary splendor, by the ridg of some house, or some other screen, so as to have left visible only the grove of the Moon, the horns excluded, he might have seen it all alike luminous.

SIMPLY, I think, now I remember; that he writes of his making use of such another Artifice, to hide from us the false *lucidum*.

The Moons Discus in a solar Eclipse can be seen only by privation.

SALV. Oh! how is this (as I believed) inadvertency of his, changed into a lie; bordering on rashness; for that every one may frequently make proof of the contrary. That in the next place, at the Suns Eclipse, the Moons *Discus* is seen otherwayes than by privation, I much doubt, and specially when the Eclipse is not total, as those must necessarily have been, which were observed by the Author; but if also he should have discovered somewhat of light, this contradicts not, rather favoureth our opinion; for that at such a time, the whole Terrestrial Hemisphere illuminated by the Sun, is opposite to the Moon, so that although the Moons shadow doth obscure a part thereof, yet this is very small in comparison of that which remains illuminated. That which he farther adds, that in this case, the part of the limb, lying under the Sun, doth appear very lucid, but that which lyeth besides it, not so; and that to proceed from the coming of the solar rayes directly through that part to the eye, but not through this, is really one of those fopperies, which discover the other fictions, of him which relates them: For if it be requisite to the making a secondary light visible in the lunar *Discus*, that the rayes of the Sun came directly through it to our eyes, doth not this pitiful Philosopher perceive, that we should never see this same secondary light, save onely at the Eclipse of the Sun? And if a part onely of the Moon, far lesse than half a degree, by being remote from the Suns *Discus*, can deflect or deviate the rayes of the Sun, so that they arrive not at our eye; what shall it do when it is distant twenty or thirty degrees, as it is at its first apparition? and what course shall the rayes of the Sun keep, which are to passe thorow the body of the Moon, that they may find out our eye? This man doth go successively considering what things ought to be, that they may serve his purpose, but doth not gradually proceed, accommodating his conceits to the things, as really they are. As for instance, to make the light of

The Author of the Book of conclusions, accommodates the things to his purposes, and not his purposes to the things.

of the Sun capable to penetrate the substance of the Moon, he makes her in part diaphanous, as is e. g. the transparence of a cloud, or cryстал: but I know not what he would think of such a transparency, in case the solar rayes were to passe a depth of clouds of above two thousand miles; but let it be supposed that he should boldly answer, that might well be in the Cœlestial, which are quite other things from these our Elementary, impure, and feculent bodies; and let us convict his error by such wayes, as admit him no reply, or (to say better) subter-fuge. If he will maintain, that the substance of the Moon is diaphanous, he must say that it is so, whilest that the rayes of the Sun are to penetrate its whole profundity, that is, more than two thousand miles; but that if you oppose unto them onely one mile, or lesse, they should no more penetrate that, than they penetrate one of our mountains.

SAGR. You put me in mind of a man, who would have sold me a secret how to correspond, by means of a certain sympathy of magnetick needles, with one, that should be two or three thousand miles distant; and I telling him, that I would willingly buy the same, but that I desired first to see the experiment thereof, and that it did suffice me to make it, I being in one Chamber, and he in the next, he answered me, that in so small a distance one could not so well perceive the operation; whereupon I turn'd him going, telling him, that I had no mind, at that time, to take a journey unto *Grand Cairo*, or to *Muscovy*, to make the experiment; but that, if he would go himself, I would perform the other part, staying in *Venice*. But let us hear whither the deduction of our Author tendeth, and what necessity there is, that he must grant the matter of the Moon to be most perforable by the rayes of the Sun, in a depth of two thousand miles, but more opacous than one of our mountains, in a thicknesse of one mile onely.

SALV. The very mountains of the Moon themselves are a proof thereof, which percussed on one side of the Sun, do cast on the contrary side very dark shadows, terminate, and more distinct by much, than the shadows of ours; but had these mountains been diaphanous, we could never have come to the knowledge of any unevennesse in the superficies of the Moon, nor have seen those luminous montuosities distinguished by the terms which separate the lucid parts from the dark: much lesse, should we see this same term so distinct, if it were true, that the Suns light did penetrate the whole thicknesse of the Moon; yea rather, according to the Authors own words, we should of necessity discern the passage, and confine, between the part of the Sun seen, and the part not seen; to be very confused, and mixt with light and dark-

A jest put upon one that would sell a certain secret for holding correspondence with a person a thousand miles off.

darknesse; for that that matter which admits the passage of the Suns rayes thorow a space of two thousand miles; must needs be so transparent, that it would very weakly resist them in a hundredth, or lesser part of that thicknesse; neverthelesse, the term which separateth the part illuminated from the obscure, is incident, and as distinct, as white is distinct from black; and especially where the Section passeth through the part of the Moon, that is naturally more clear and montanous; but where the old spots do part, which are certain plains, that by means of their spherical inclination, receive the rayes of the Sun obliquely, there the term is not so distinct, by reason of the more dimme illumination. That, lastly, which he saith, how that the secondary light doth not diminish and languish, according as the Moon encreaseth, but conserveth it self continually in the same efficacy; is most false; nay it is hardly seen in the quadrature, when, on the contrary, it should appear more splendid, and be visible after the *crepusculum* in the dark of night. Let us conclude therefore, that the Earths reflection is very strong upon the Moon; and that, which you ought more to esteem, we may deduce from thence another admirable congruity between the Moon and Earth; namely,

The Earth may reciprocally operate upon Cœlestial bodies, with its light.

ly, that if it be true, the Planets operate upon the Earth by their motion and light, the Earth may probably be no lesse potent in operating reciprocally upon them with the same light, and peradventure, motion also. And though it should not move, yet may it retain the same operation; because, as it hath been proved already, the action of the light is the self same, I mean of the light of the Sun reflected; and motion doth nothing, save only vary the aspects, which fall out in the same manner, whether we make the Earth move, and the Sun stand still, or the contrary.

SIMPL. None of the Philosophers are found to have said, that these inferiour bodies operate on the Cœlestial, nay, *Aristotle* affirms the direct contrary.

SALV. *Aristotle* and the rest, who knew not that the Earth and Moon mutually illuminated each other, are to be excused; but they would justly deserve our censure, if whilst they desire that we should grant and believe with them, that the Moon operateth upon the Earth with light, they should deny to us, who have taught them that the Earth illuminates the Moon, the operation the Earth hath on the Moon.

SIMPL. In short, I find in my self a great unwillingnesse to admit this commerce, which you would perswade me to be betwixt the Earth and Moon, placing it, as we say, amongst the number of the Stars; for if there were nothing else, the great separation and distance between it and the Cœlestial bodies, doth in my opinion necessarily conclude a vast disparity between them.

SALV.

SALV. See *Simplicius* what an inveterate affection and radical opinion can do, since it is so powerful, that it makes you think that those very things favour you; which you produce against your self. For if separation and distance are accidents sufficient to persuade with you a great diversity of natures, it must follow that proximity and contiguity import similitude. Now how much more nearer is the Moon to the Earth, than to any other of the Cælestial Orbs? You must acknowledg therefore, according to your own concession (and you shall have other Philosophers bear you company) that there is a very great affinity betwixt the Earth and Moon. Now let us proceed, and see whether any thing remains to be considered, touching those objections which you made against the resemblances that are between these two bodies.

*Affinity between
the Earth & Moon
in respect of their
vicinity.*

SIMPL. It rests, that we say something touching the solidity of the Moon, which I argued from its being exquisite smooth and polite; and you from its montuosity. There is another scruple also comes into my mind; from an opinion which I have, that the Seas reflection ought by the equality of its surface, to be rendered stronger than that of the Earth, whose superficies is so rough and opacous.

SALV. As to the first objection; I say, that like as among the parts of the Earth, which all by their gravity strive to approach the nearest they can possible to the center, some of them alwayes are more remote from it than the rest, as the mountains more than the valleys; and that by reason of their solidity and firmnesse (for if they were of fluid, they would be even) so the seeing some parts of the Moon to be elevated above the sphericity of the lower parts, argueth their hardnesse; for it is probable that the matter of the Moon is reduced into a spherical form by the harmonious conspiracy of all its parts to the same sentence. Touching the second doubt, my thinks that the particulars already observed to happen in the Looking-glasses, may very well assure us, that the reflection of light comming from the Sea, is far weaker than that which cometh from Land; understanding it alwayes of the universal reflection; for as to that particular, on which the water being calm, casteth upon a determinate place; there is no doubt, but that he who shall stand in that place, shall see a very great reflection in the water, but every way else he shall see the surface of the Water more obscure than that of the Land; and to prove it to your senses, let us go into yonder Hall, and pour forth a little water upon the Pavement. Tell me now, doth not this wet brick shew more dull than the other dry ones? Doubtlesse it doth, and will so appear, from what place soever you behold it; except one onely, and this is that way which the light cometh, that entereth in at yonder window; go backwards therefore by a little and a little.

*Solidity of the
Lunar Globe argu-
ed from its being
mountainous.*

*The Seas reflec-
tion of light much
weaker than that
of the Earth.*

*An experiment
to prove the reflec-
tion of the water,
lesse clear than
that of the Land.*

L

SIMPL.

SIMPL. Here I see the west part shine more than all the rest of the pavement, and I see that it so hapneth, because the reflection of the light which entereth in at the window, cometh towards me.

SALV. That moisture hath done no more but filled those little cavities which are in the brick with water, and reduced its superficies to an exact evenesse; whereupon the reflex rayes issue unitedly towards one and the same place; but the rest of the pavement which is dry, hath its protuberances, that is, an innumerable variety of inclinations in its smallest particles; whereupon the reflections of the light scatter towards all parts; but more weakly than if they had gone all united together; and therefore, the same sheweth almost all alike, beheld several wayes, but far lesse clear than the moistned brick. I conclude therefore, that the surface of the Sea, beheld from the Moon, in like manner, as it would appear most equal, (the Islands and Rocks deducted) so it would shew lesse clear than that of the Earth, which is mountainous and uneven. And but that I would not seem, as the saying is, to harp too much on one string, I could tell you that I have observed in the Moon that secondary light which I told you came to her from the reflection of the Terrestrial Globe, to be notably more clear two or three dayes before the conjunction, than after, that is, when we see it before break of day in the East, than when it is seen at night after Sun-set in the West; of which difference the cause is, that the Terrestrial Hemisphere, which looks towards the Eastern Moon, hath little Sea, and much Land, to wit, all *Asia*, whereas, when it is in the West, it beholds very great Seas, that is, the whole *Atlantick* Ocean as far as *America*: An Argument sufficiently probable that the surface of the water appears lesse splendid than that of the Earth.

The secondary light of the Moon clearer before the conjunction, than after.

SIMPL. So that perhaps you believe, those great spots discovered in the face of the Moon, to be Seas, and the other clearer parts to be Land, or some such thing?

SALV. This which you ask me, is the beginning of those incongruities which I esteem to be between the Moon and the Earth, out of which it is time to dis-engage our selves, for we have stayed too long in the Moon. I say therefore, that if there were in nature but one way onely, to make two superficieses illustrated by the Sun, to appear one more clear than the other, and that this were by the being of the one Earth, and the other Water; it would be necessary to say that the surface of the Moon were part earthy and part aquatick; but because we know many wayes to produce the same effect (and others there may be which we know not of;) therefore I dare not affirm the Moon to consist of one thing more than another: It hath been seen already that

that a silver plate boiled, being toucht with the Burnisher, becometh of white obscure; that the moist part of the Earth shews more obscure than the dry; that in the tops of Hills, the woody parts appear more gloomy than the naked and barren; which hapneth becaule there falleth very much shadow among the Trees, but the open places are illuminated all over by the Sun. And this mixtion of shadow hath such operation, that in tufted velvet, the silk which is cut, is of a far darker colour than that which is not cut, by means of the shadows diffused betwixt thred and thred, and a plain velvet shews much blacker than a Taffata, made of the same silk. So that if there were in the Moon things which should look like great Woods, their aspect might represent unto us the spots which we discover; alike difference would be occasioned, if there were Seas in her: and lastly, nothing hindreth, but that those spots may really be of an obscurer colour than the rest; for thus the snow makes the mountains shew brighter. That which is plainly observed in the Moon is, that its most obscure parts are all plains, with few rises and bancks in them; though some there be; the rest which is of a brighter colour, is all full of rocks, mountains, hillocks of spherical and other figures; and in particular, round about the spots are very great ledges of mountains. That the spots be plain superficies, we have assured proof, in that we see, how that the term which distinguisheth the part illuminated from the obscure, in crossing the spots makes the interfection even, but in the clear parts it shews all craggy and shagged. But I know not as yet whether this evenesse of superficies may be sufficient of it self alone, to make the obscurity appear, and I rather think not. Besides, I account the Moon exceeding different from the Earth; for although I imagine to my self that those are not idle and dead Regions, yet I affirm not, that there are in them motion and life, much less that there are bred plants, animals or other things like to ours; but, if such there be, they should nevertheless be very different, and remote from our imagination. And I am induced so to think, because in the first place, I esteem that the matter of the Lunar Globè consists not of Earth and Water; and this alone sufficeth to take away the generations and alterations resembling ours: but now supposing that there were in the Moon, Water and Earth, yet would they not produce plants and animals like to ours; and this for two principal reasons: The first is, that unto our productions there are required so many variable aspects of the Sun, that without them they would all miscarry: now the habitudes of the Sun towards the Earth are far different from those towards the Moon. We as to the diurnal illumination, have, in the greater part of the Earth, every twenty four hours part day, and part night, which effect in the Moon is monethly: and that annual decli-

The obscurer parts of the Moon are plains, and the more bright mountainous.

Long ledges of mountains about the spots of the Moon.

There are not generated in the Moon things like to ours, but if there be any productions, they are very different.

The Moon was composed of Water and Earth.

Those aspects of the Sun necessary for our generations, are not so in the Moon.

*Natural dayes
in the Moon are of
a Moneth long.*

*To the Moon
the Sun ascendeth
and declineth with
a difference of ten
degrees, and to the
Earth of forty se-
ven degrees.*

*There are no
rains in the Moon.*

*The having a
perfect knowledge
of nothing, maketh
some believe they
understand all
things.*

nation and elevation of the Sun in the Zodiack, by which it produceth diversity of Seasons, and inequality of dayes and nights, are finished in the Moon in a moneth; and whereas the Sun to us riseth and declineth so much, that from the greatest to the least altitude, there is a difference of almost 47 degrees, for so much is the distance from one to the other Tropick; this is in the Moon but ten degrees only, or little more; namely, as much as the greatest Latitudes of the Dragon on each side the Ecliptick. Now consider what effect the Sun would have in the torrid Zone, should it continually for fifteen dayes together beam forth its Rayes upon it; which without all question would destroy plants, herbs, and living creatures; and if it should chance that there were any production, it would be of herbs, plants, and creatures very different from those which are now there. Secondly, I verily believe that in the Moon there are no rains, for if Clouds should gather in any part thereof, as they do about the Earth, they would thereupon hide from our sight some of those things, which we with the Telescope behold in the Moon, and in a word, would some way or other change its *Phenomenon*, an effect which I could never by long and diligent observations discover; but alwayes beheld it in a even and pure serenity.

SAGR. To this may be answered, either that there might be great mists, or that it might rain in the time of their night, that is, when the Sun doth not illuminate it.

SALV. If other passages did but assure us, that there were generations in it like to ours, and that there was onely wanting the concurrence of rains; we might find out this, or some other temperament to serve instead thereof, as it happens in Egypt by the inundation of Nile: but not meeting with any accident, which corresponds with ours, of many that have been sought out for the production of the like effects, we need not trouble our selves to introduce one alone; and that also, not because we have certain observation of it, but for a bare non-repugnance that we find therein. Moreover, if I was demanded what my first apprehension, and pure natural reason dictated to me concerning the production of things like or unlike there above, I would alwayes reply, that they are most different, and to us altogether unimaginable, for so me thinks the riches of Nature, and the omnipotence of our Creator and Governour, do require.

SAGR. I ever accounted extraordinary madnesse that of those, who would make humane comprehension the measure of what nature hath a power or knowledge to effect; whereas on the contrary there is not any the least effect in Nature, which can be fully understood by the most speculative wits in the world. This their so vain presumption of knowing all, can take beginning from nothing

thing, unlesse from their never having known any thing; for if one hath but once onely experienced the perfect knowledg of one onely thing, and but truly tasted what it is to know, he shall perceive that of infinite other conclusions, he understands not so much as one.

SALV. Your discourse is very concluding; in confirmation of which we have the example of those who understand, or have known some thing, which the more knowing they are, the more they know; and freely confesse that they know little; nay, the wisest man in all Greece, and for such pronounced by the Oracle, openly professed to know that he knew nothing.

SIMPL. It must be granted therefore, either that Socrates or that the Oracle it self was a lyar, that declaring him to be most wise, and he confessing that he knew himself to be most ignorant.

SALV. Neither one nor the other doth follow, for that both the assertions may be true. The Oracle adjudged Socrates the wisest of all men, whose knowledg is limited; Socrates acknowledged that he knew nothing in relation to absolute wisdom, which is infinite; and because of infinite, much is the same part, as is little, and as is nothing (for to arrive v. g. to the infinite number, it is all one to accumulate thousands, tens, or ciphers,) therefore Socrates well perceived his wisdom to be nothing, in comparison of the infinite knowledg which he wanted. But yet, because there is some knowledg found amongst men, and this not equally shared to all, Socrates might have a greater share thereof than others, and therefore verified the answer of the Oracle.

The answer of the Oracle true in judging Socrates the wisest of his time.

SAGG. I think I very well understand this particular amongst men; *Simplivius* there is a power of operating, but not equally dispensed to all; and it is without question, that the power of an Emperor is far greater than that of a private person; but, both this and that are nothing in comparison of the Divine Omnipotence. Amongst men, there are some that better understand Agriculture than many others; but the knowledg of planting a Vine in a trench, what hath it to do with the knowledg of making it to sprout forth, to attract nourishment, to select this good part from that other, for to make thereof leaves, another to make sprouts, another to make grapes, another to make raisins, another to make the huskes of them, which are the works of most wise Nature? This is one only particular act of the innumerable, which Nature doth, and in it alone is discovered an infinite wisdom, so that Divine Wisdom may be concluded to be infinitely infinite.

Divine Wisdom infinitely infinite.

SALV. Take hereof another example. Do we not say that the judi-

Buonarruotti, a
statuary of admi-
rable ingenuity.

judicious discovering of a most lovely *Statua* in a piece of Marble, hath sublimated the wit of *Buonarruotti* far above the vulgar wits of other men? And yet this work is onely the imitation of a meer aptitude and disposition of exterior and superficial members of an immoveable man; but what is it in comparison of a man made by nature, composed of as many exterior and interior members, of so many muscles, tendons, nerves, bones, which serve to so many and sundry motions? but what shall we say of the senses, and of the powers of the soul, and lastly, of the understanding? May we not say, and that with reason, that the structure of a Statue falls far short of the formation of a living man, yea more of a contemptible worm?

SAGR. And what difference think you, was there betwixt the Dove of *Architas*, and one made by Nature?

SIMPL. Either I am none of these knowing men, or else there is a manifest contradiction in this your discourse. You account understanding amongst the greatest (if you make it not the chief of the) *Encomiums* ascribed to man made by Nature, and a little before you said with *Socrates*, that he had no knowledg at all; therefore you must say, that neither did Nature understand how to make an understanding that understandeth.

Man understandeth
very well in-
tensive, but little
extensive.

SALV. You argue very cunningly, but to reply to your objection I must have recourse to a Philosophical distinction, and say that the understanding is to be taken two ways, that is *intensive*, or *extensive*; and that *extensive*, that is, as to the multitude of intelligibles, which are infinite, the understanding of man is as nothing, though he should understand a thousand propositions; for that a thousand, in respect of infinity is but as a cypher: but taking the understanding *intensive*, (in as much as that term imports) intensively, that is, perfectly some propositions, I say, that humane wisdom understandeth some propositions so perfectly, and is as absolutely certain thereof, as Nature her self; and such are the pure Mathematical sciences, to wit, Geometry and Arithmetick: in which Divine Wisdom knows infinite more propositions, because it knows them all; but I believe that the knowledge of those few comprehended by humane understanding, equalleth the divine, as to the certainty *objective*, for that it arriveth to comprehend the necessity thereof, than which there can be no greater certainty.

SIMPL. This seemeth to me a very bold and rash expression.

SALV. These are common notions, and far from all umbrage of temerity, or boldness, and detract not in the least from the Majesty of divine wisdom; as it nothing diminisheth the omnipotence thereof to say, that God cannot make what is once done, to be undone: but I doubt, *Simplicius*, that your scruple ariseth from an opinion you have, that my words are somewhat equivocal; therefore

fore the better to exprefs my ſelf I ſay, that as to the truth, of which Mathematical demonſtrations give us the knowledge, it is the ſame, which the divine wiſdom knoweth; but this I muſt grant you, that the manner whereby God knoweth the infinite propoſitions, of which we underſtand ſome few, is highly more excellent than ours, which proceedeth by ratiocination, and paſſeth from con- cluſion to concluſion; whereas his is done at one ſingle thought or intuition; and whereas we, for example, to attain the knowledg of ſome paſſion of the Circle, which hath infinite, beginning from one of the moſt ſimple, and taking that for its definition, do proceed with argumentation to another, and from that to a third, and then to a fourth, &c. the Divine Wiſdom, by the apprehenſion of its eſſence comprehends, without temporary ratiocination, all theſe infinite paſſions; which notwithstanding, are in effect virtually comprized in the definitions of all things; and, to conclude, as being infinite, perhaps are but one alone in their nature, and in the Divine Mind; the which neither is wholly unknown to humane underſtanding, but onely be-clouded with thick and groſſe miſts; which come in part to be diſſipated and clarified, when we are made Maſters of any concluſions, firmly demon- ſtrated; and ſo perfectly made ours, as that we can ſpeedily run through them; for in ſum, what other, is that propoſition, that the ſquare of the ſide ſubtending the right angle in any triangle, is equal to the ſquares of the other two, which include it, but onely the Parallelograms being upon common baſes, and between parallels equal amongſt themſelves? and this, laſtly, is it not the ſame, as to ſay that thoſe two ſuperficies are equal, of which equal parts applyed to equal parts, poſſeſſe equal place? Now theſe inferences, which our intellect apprehendeth with time and a gradual motion, the Divine Wiſdom, like light, penetrateth in an inſtant, which is the ſame as to ſay, hath them alwayes pre- ſent: I conclude therefore, that our underſtanding, both as to the manner and the multitude of the things comprehended by us, is infinitely ſurpaſt by the Divine Wiſdom; but yet I do not ſo vilifie it, as to repute it abſolutely nothing; yea rather, when I conſider how many and how great miſteries men have underſtood, diſcovered, and contrived; I very plainly know and underſtand the mind of man to be one of the works, yea one of the moſt ex- cellent works of God.

SAGR. I have oft times conſidered with my ſelf, in purſuance of that which you ſpeak of, how great the wit of man is; and whilſt I run thorow ſuch and ſo many admirable inventions found out by him, as well in the Arts, as Sciences; and again reflecting upon my own wit, ſo far from promiſing me the diſcovery of any thing new, that I deſpair of comprehending what is already diſ- covered;

Gods manner of knowing different from that of men. Humane under- ſtanding done by ratiocination.

Definitions com- prehend virtually all the paſſions of the things defined. Infinite Paſſions are perhaps but one onely.

The diſcourſes which humane reaſon makes in a certain time, the Divine Wiſdom re- ſolveth in a mo- ment; that is, hath them alwayes pre- ſent.

The wit of man admirably acute.

covered, confounded with wonder, and surpris'd with desperation, I account my self little lesse than miserable. If I behold a Statue of some excellent Master, I say with my self; When wilt thou know how to chizzle away the refuse of a piece of Marble, and discover so lovely a figure, as lyeth hid therein? When wilt thou mix and spread so many different colours upon a Cloth, or Wall, and represent therewith all visible objects, like a *Michael Angelo*, a *Raphaello*, or a *Tizvano*? If I behold what inventions men have in comparting Musical intervals, in establishing Precepts and Rules for the management thereof with admirable delight to the ear: When shall I cease my astonishment? What shall I say of such and so various Instruments of that Art? The reading of excellent Poets, with what admiration doth it swell any one that attentively considereth the invention of conceits, and their explanation? What shall we say of Architecture? What of Navigation? But, above all other stupendious inventions, what sublimity of mind was that in him, that imagined to himself to find out a way to communicate his most secret thoughts to any other person, though very far distant from him either in time, or place, speaking with those that are in the *India's*; speaking to those that are not yet born, nor shall be this thousand, or ten thousand years? and with how much facility? but by the various collocation of * twenty little letters upon a paper? Let this be the Seal of all the admirable inventions of man, and the close of our Discourse for this day: For the warmer hours being past, I suppose that *Salviatus* hath a desire to go and take the air in his Gondelo; but too morrow we will both wait upon you, to continue the Discourses we have begun, &c.

*The invention of
writing stupendous
above all others.*

* For of so many
only the Italian
Alphabet consists.

GAL-

GALILÆUS
Galilæus Lyncæus,
HIS
SYSTEME
OF THE
WORLD.

The Second Dialogue.

INTERLOCUTORS.

SALVIATUS, SAGREDUS, and SIMPLICIUS.

SALV.



He yester-dayes diversions which led us out of the path of our principal discourse, were such and so many, that I know not how I can without your assistance recover the track in which I am to proceed.

SAGR. I wonder not, that you, who have your fancy charged and laden with both what hath been, and is to be spoken, do find your self in some confusion; but I, who as being onely an Auditor, have nothing to burthen my memory withal, but such things as I have heard, may haply by a succinct rehearsal of them, recover the first thread of our Discourse. As far therefore as my memory serves me, the sum of yester-dayes conferences were an examination of the Principles

M

ciples of *Ptolomy* and *Copernicus*, and which of their opinions is the more probable and rational; that, which affirmeth the substance of the Cœlestial bodies to be ingenerable, incorruptible, unalterable, impassible, and in a word, exempt from all kind of change, save that of local, and therefore to be a *fifth essence*, quite different from this of our Elementary bodies, which are generable, corruptible, alterable, &c. or else the other, which taking away such deformity from the parts of the World, holdeth the Earth to enjoy the same perfections as the other integral bodies of the universe; and esteemeth it a moveable and erratick Globe, no lesse than the Moon, *Jupiter*, *Venus*, or any other Planet: And lastly, maketh many particular parallels betwixt the Earth and Moon; and more with the Moon, than with any other Planet; haply by reason we have greater and more certain notice of it, as being lesse distant from us. And having, lastly, concluded this second opinion to have more of probability with it than the first, I should think it best in the subsequent discourses to begin to examine whether the Earth be esteemed immoveable, as it hath been till now believed by most men, or else moveable, as some ancient *Philosophers* held, and others of not very reccessive times, were of opinion; and if it be moveable, to enquire of what kind its motion may be?

SALV. I see already what way I am to take; but before we offer to proceed any farther, I am to say something to you touching those last words which you spake, how that the opinion which holds the Earth to be endued with the same conditions that the Cœlestial bodies enjoy, seems to be more true than the contrary; for that I affirmed no such thing, nor would I have any of the Propositions in controversie, be made to speak to any definitive sense: but I onely intended to produce on either part, those reasons and answers, arguments and solutions, which have been hitherto thought upon by others, together with certain others, which I have stumbled upon in my long searching thereinto, alwayes remitting the decision thereof to the judgment of others.

SAGR. I was unawares transported by my own sense of the thing; and believing that others ought to judg as I did, I made that conclusion universal, which should have been particular; and therefore confesse I have erred, and the rather, in that I know not what *Simplicius* his judgment is in this particular.

SIMPL. I must confesse, that I have been ruminating all this night of what past yesterday, and to say the truth, I meet therein with many acute, new, and plausible notions; yet nevertheless, I find my self over-perswaded by the authority of so many great Writers, and in particular ——— &c. I see you shake your head *Sagredus*, and smile to your self, as if I had uttered some great absurdity.

SAGR.

SAGR. I not onely smile, but to tell you true, am ready to burst with holding in my self from laughing outright, for you have put me in mind of a very pretty passage, that I was a witness of, not many years since, together with some others of my worthy friends, which I could yet name unto you.

SALV. It would be well that you told us what it was; that so *Simplicius* may not still think that he gave you the occasion of laughter.

SAGR. I am content. I found one day, at home in his house, at Venice, a famous Physician, to whom some flockt for their studies, and others out of curiosity, sometimes came thither to see certain Anatomies dissected by the hand of a no lesse learned, than careful and experienced Anatomist. It chanced upon that day, when I was there, that he was in search of the original and rise of the Nerves, about which there is a famous controversie between the *Galenists* and *Peripateticks*; and the Anatomist shewing, how that the great number of Nerves departing from the Brain, as their root, and passing by the nape of the Neck, distend themselves afterwards along by the Backbone, and branch themselves thorow all the Body; and that a very small filament, as fine as a thred went to the Heart, he turned to a Gentleman whom he knew to be a *Peripatetick* Philosopher, and for whose sake he had with extraordinary exactnesse, discovered and proved every thing, and demanded of him, if he was at length satisfied and perswaded that the original of the Nerves proceeded from the Brain, and not from the Heart. To which the Philosopher, after he had stood musing a while, answered; you have made me to see this businesse so plainly and sensibly, that did not the Text of *Aristotle* asserth the contrary, which positively affirmeth the Nerves to proceed from the Heart, I should be constrained to confesse your opinion to be true.

The original of the Nerves according to Aristotle, and according to Physicians.

The ridiculous answer of a Philosopher, determining the original of the Nerves.

SIMPL. I would have you know my Masters, that this controversie about the original of the Nerves is not yet so proved and decided, as some may perhaps perswade themselves.

SAGR. Not questionlesse ever shall it be, if it find such like contradictors; but that which you say, doth not at all lessen the extravagance of the answer of that *Peripatetick*, who against such sensible experience produced not other experiments; or reasons of *Aristotle*, but his bare authority and pure *ipse dixit*.

SIMPL. *Aristotle* had not gained so great authority, but for the force of his Demonstrations; and the profoundnesse of his arguments; but it is requisite that we understand him; and not onely understand him; but have so great familiarity with his Books, that we form a perfect *Idea* thereof in our minds, so as that every saying of his may be alwayes as it were, present in our

*Requisite to fit
a man to philoso-
phate well after
the manner of A-
ristotle.*

*A cunning way
to gather Philoso-
phy out of any book
whatsoever.*

** A word signify-
ing works compo-
sed of many frag-
ments of verses
collected out of the
Poets.*

*Invention of the
Telescope taken
from Aristotle.*

memory for he did not write to the vulgar, nor is he obliged to spin out his Sillogismes with the trivial method of disputes; nay rather, using a freedome, he hath sometimes placed the proof of one Proposition amongst Texts, which seem to treat of quite another point; and therefore it is requisite to be master of all that vast *Idea*, and to learn how to connect this passage with that, and to combine this Text with another far remote from it; for it is not to be questioned but that he who hath thus studied him, knows how to gather from his Books the demonstrations of every knowable deduction, for that they contain all things.

SAGR. But good *Simplicius*, like as the things scattered here and there in *Aristotle*, give you no trouble in collecting them, but that you perswade your self to be able by comparing and connecting several small sentences to extract thence the juice of some desired conclusion, so this, which you and other egregious Philosophers do with the Text of *Aristotle*, I could do by the verses of *Virgil*, or of *Ovid*, composing thereof * *Centones*, and therewith explaining all the affairs of men, and secrets of Nature. But what talk I of *Virgil*, or any other Poet? I have a little Book much shorter than *Aristotle* and *Ovid*, in which are contained all the Sciences, and with very little study, one may gather out of it a most perfect *Idea*, and this is the *Alphabet*; and there is no doubt but that he who knows how to couple and dispose aright this and that vowel, with those, or those other consonants, may gather thence the infallible answers to all doubts, and deduce from them the principles of all Sciences and Arts, just in the same manner as the Painter from divers simple colours, laid severally upon his *Pallate*, proceedeth by mixing a little of this and a little of that, with a little of a third, to represent to the life men, plants, buildings, birds, fishes, and in a word, counterfeiting what ever object is visible, though there be not on the *Pallate* all the while, either eyes, or feathers, or fins, or leaves, or stones. Nay, farther, it is necessary, that none of the things to be imitated, or any part of them, be actually among colours, if you would be able therewith to represent all things; for should there be amongst them *v. gr.* feathers, these would serve to represent nothing save birds, and plumed creatures.

SALV. And there are certain Gentlemen yet living, and in health, who were present, when a Doctor, that was Professor in a famous Academy, hearing the description of the *Telescope*, by him not seen as then, said, that the invention was taken from *Aristotle*, and causing his works to be fetch't, he turned to a place where the Philosopher gives the reason, whence it commeth, that from the bottom of a very deep Well, one may see the stars in Heaven, at noon day; and, addressing himself to the company, see

DIALOGUE II.

93

see here, saith he, the Well, which representeth the Tube, see here the gross vapours, from whence is taken the invention of the Crystals, and see here lastly the light fortified by the passage of the rays through a diaphanous; but more dense and obscure medium.

SAGR. This is a way to comprehend all things knowable, much like to that wherewith a piece of marble containeth in it one, yea, a thousand very beautiful Statua's, but the difficulty lieth in being able to discover them; or we may say, that it is like to the prophecies of Abbot *Joachim*, or the answers of the Heathen *Oracles*, which are not to be understood, till after the things fore-told are come to passe.

SALV. And why do you not adde the predictions of the *Gaezethliacks*, which are with like cleernesse seen after the event, in their Horoscopes, or, if you will, Configurations of the Heavens.

SAGR. In this manner the Chymists find, being led by their melancholly humour; that all the sublimest wits of the World have writ of nothing else in reality, than of the way to make Gold; but, that they might transmit the secret to posterity without discovering it to the vulgar, they contrived some one way, and some another how to conceal the same under several maskes; and it would make one merry to hear their comments upon the ancient *Poets*, finding out the important misteries, which lie hid under their Fables; and the signification of the Loves of the *Moon*, and her descending to the Earth for *Endimion*; her displeasure against *Aceon*, and what was meant by *Jupiter* turning himself into a shewre of Gold; and into flames of fire; and what great secrets of Art are contained in that *Mercury* the Interpreter; in those thefts of *Pluto*; and in those Branches of Gold.

SIMP. I believe, and in part know, that there want not in the World very extravagant heads, the vanities of whom ought not to redound to the prejudice of *Aristotle*, of whom my thinks you speak sometimes with too little respect, and the onely antiquity and bare name that he hath acquired in the opinions of so many famous men, should suffice to render him honourable with all that professe themselves learned.

SALV. You state not the matter rightly, *Simplicius*; There are some of his followers that fear before they are in danger, who give us occasion, or, to say better, would give us cause to esteem him lesse, should we consent to applaud their *Capricio's*. And you, pray you tell me, are you for your part so simple, as not to know that had *Aristotle* been present, to have heard the Doctor that would have made him Author of the Telescope, he would have been much more displeased with him, than with those, who laugh at the Doctor and his Comments? Do you question whe-

Chymists interpret the Fables of the Poets to be secrets for making of Gold.

Some of Aristotles Selfators im- pare the reputation of their Master, in going about to enhance it.

whether *Aristotle*, had he but seen the novelties discovered in Heaven, would not have changed his opinion, amended his Books, and embraced the more sensible Doctrine; rejecting those silly Gulls, which too scrupulously go about to defend what ever he hath said; not considering, that if *Aristotle* were such a one as they fancy him to themselves, he would be a man of an untractable wit, an obstinate mind, a barbarous soul, a stubborn will, that accounting all men else but as silly sheep, would have his Oracles preferred before the Senses, Experience, and Nature herself. They are the Sectators of *Aristotle* that have given him this Authority; and not he that hath usurped or taken it upon him; and because it is more easie for a man to sculk under anothers shield than to shew himself openly, they tremble, and are afraid to stir one step from him; and rather than they will admit some alterations in the Heaven of *Aristotle*, they will impertinently deny those they behold in the Heaven of Nature.

*A ridiculous
passage of a certain
Statuary.*

SAG N. These kind of Drolleries put me in mind of that Statuary which having reduced a great piece of Marble to the Image of an *Hercules*, or a thundring *Jupiter*, I know not whether, and given it with admirable Art such a vivacity and threatening fury, that it moved terror in as many as beheld it; he himself began also to be afraid thereof, though all its sprightfulness, and life was his own workmanship; and his affrightment was such, that he had no longer the courage to affront it with his Chizzels and Mallet.

SAG Y. I have many times wondered how these nice maintainers of what ever fell from *Aristotle*, are not aware how great a prejudice they are to his reputation and credit; and how that the more they go about to encrease his Authority, the more they diminish it; for whilest I see them obstinate in their attempts to maintain those Propositions which I palpably discover to be manifestly false; and in their desires to persuade me that so to do, is the part of a Philosopher; and that *Aristotle* himself would do the same, it much abates in me of the opinion that he hath rightly philosophated about other conclusions, to me more abstruse: for if I could see them concede and change opinion in a manifest truth, I would believe, that in those in which they should persist, they may have some solid demonstrations to me unknown, and unheard of.

SAG N. Or when they should be made to see that they have hazarded too much of their own and *Aristotle's* reputation in confessing that they had not understood this or that conclusion found out by some other man; would it not be a less evil for them to seek for it amongst his Texts, by laying many of them together, according to the art intimated to us by *Simplicius*? for if his

works

DIALOGUE. II.

55

works contain all things knowable, it must follow also that they may be therein discovered.

SALV. Good *Sagredus*, make no jest of this advice, which me thinks you rehearse in too Ironical a way; for it is not long since that a very eminent Philosopher having composed a Book *de anima*, wherein, citing the opinion of *Aristotle*, about its being or not being immortal, he alledged many Texts, (not any of those heretofore quoted by *Alexander ab Alexandro*: for in those he said, that *Aristotle* had not so much as treated of that matter, much less determined any thing pertaining to the same, but others) by himself found out in other more abstruse places, which tended to an erroneous sense: and being advised, that he would find it an hard matter to get a Licence from the Inquisitors, he writ back unto his friend, that he would notwithstanding, with all expedition procure the same, for that if no other obstacle should interpose, he would not much scruple to change the Doctrine of *Aristotle*, and with other expositions, and other Texts to maintain the contrary opinion, which yet should be also agreeable to the sense of *Aristotle*.

A brave resolution of a certain Peripatetick Philosopher.

SAGR. Oh most profound Doctor, this I that can command me that I stir not a step from *Aristotle*, but will himself lead him by the nose, and make him speak as he pleaseth. See how much it importeth to learn to take Time by the Fore-top. Nor is it seasonable to have to do with *Hercules*, whilst he is enraged, and amongst the Furies, but when he is telling merry tales amongst the *Meonian Damosels*. Ah, unheard of fordidnesse of servile souls! to make themselves willing slaves to other mens opinions; to receive them for inviolable Decrees, to engage themselves to seem satisfied and convinced by arguments, of such efficacy, and so manifestly concludent, that they themselves cannot certainly resolve whether they were really writ to that purpose, or serve to prove that assumption in hand, or the contrary. But, which is a greater madnesse, they are at variance amongst themselves, whether the Author himself hath held the affirmative part, or the negative. What is this, but to make an Oracle of a Log, and to run to that for answers, to fear that, to reverence and adore that?

The servile spirit of some of Aristotles followers.

SIMPL. But in case we should recede from *Aristotle*, who have we to be our Guid in Philosophy? Name you some Author.

SALV. We need a Guid in unknown and uncouth wayes, but in champion places, and open plains, the blind only stand in need of a Leader; and for such, it is better that they stay at home. But he that hath eyes in his head, and in his mind, him should a man choose for his Guid. Yet mistake me not, thinking that I speak this, for that I am against hearing of *Aristotle*; for on the

Too close adhering to Aristotle is blameable.

CON-

It is not just, that
those who never
philosophate, should
usurp the title of
Philosophers.

The Sensible
World.

contrary, I commend the reading, and diligently studying of him; and onely blame the servile giving ones self up a slave unto him, so, as blindly to subscribe to what ever he delivers; and without search of any farther reason thereof, to receive the same for an inviolable decree. Which is an abuse, that carrieth with it another great inconvenience, to wit, that others will no longer take pains to understand the validity of his Demonstrations. And what is more shameful, than in the midst of publique disputes, whilst one person is treating of demonstrable conclusions, to hear another interpose with a passage of *Aristotle*; and not seldom writ to quite another purpose, and with that to stop the mouth of his opponent? But if you will continue to study in this manner, I would have you lay aside the name of Philosophers; and call your selves either Historians or Doctors of Memory, for it is not fit, that those who never philosophate, should usurp the honourable title of Philosophers. But it is best for us to return to shore, and not lanch farther into a boundlesse Gulph, out of which we shall not be able to get before night. Therefore *Simplicius*, come either with arguments and demonstrations of your own; or of *Aristotle*, and bring us no more Texts and naked authorities, for our disputes are about the Sensible World, and not one of Paper. And forasmuch as in our discourses yesterday, we retriev'd the Earth from darknesse, and exposed it to the open skie; shewing, that the attempt to enumerate it amongst those which we call Cœlestial bodies, was not a position so foil'd, and vanquish't, as that it had no life left in it; it followeth next, that we proceed to examine what probability there is for holding of it fixt, and wholly immoveable, *scilicet* as to its entire Globe, what likelihood there is for making it moveable with some motion, and of what kind that may be. And forasmuch as in this same question I am ambiguous, and *Simplicius* is resolute, as likewise *Aristotle* for the opinion of its immobility, he shall one by one produce the arguments in favour of their opinion, and I will alledge the answers and reasons on the contrary part; and next *Sagredus* shall tell us his thoughts, and to which side he finds himself inclined.

SAGR. Content; provided alwayes that I may reserve the liberty to my self of alledging what pure natural reason shall sometimes dictate to me.

SALV. Nay more; it is that which I particularly beg of you; for, amongst the more easie, and, to so speak, material considerations, I believe there are but few of them that have been omitted by Writers, so that onely some of the more subtle, and remote can be desired, or wanting; and to investigate these, what other ingenuity can be more fit than that of the most acute and piercing wit of *Sagredus*?

SAGR.

DIALOGUE II.

97

SAGR. I am what ever pleaseth *Salviatus*, but I pray you, let us not fall out into another kind of digression complemental; for at this time I am a Philosopher, and in the Schools, not in the Court.

SALV. Let our contemplation begin therefore with this consideration, that whatsoever motion may be ascribed to the Earth, it is necessary that it be to us, (as inhabitants upon it, and consequently partakers of the same) altogether imperceptible, and as if it were not at all; so long as we have regard onely to terrestrial things; but yet it is on the contrary, as necessary that the same motion do seem common to all other bodies; and visible objects, that being separated from the Earth, participate not of the same. So that the true method to find whether any kind of motion may be ascribed to the Earth, and that found, to know what it is, is to consider and observe if in bodies separated from the Earth, one may discover any appearance of motion, which equally suiteth to all the rest; for a motion that is onely seen, *v. gr.* in the *Moon*, and that hath nothing to do with *Venus* or *Jupiter*, or any other Stars, cannot any way belong to the Earth, or to any other save the *Moon* alone. Now there is a most general and grand motion above all others, and it is that by which the Sun, the *Moon*, the other Planets, and the Fixed Stars, and in a word, the whole Universe, the Earth onely excepted, appeareth in our thinking to move from the East towards the West, in the space of twenty four hours; and this, as to this first appearance, hath no obstacle to hinder it, that it may not belong to the Earth alone, as well as to all the World besides, the Earth excepted; for the same aspects will appear in the one position, as in the other. Hence it is that *Aristotle* and *Ptolomy*, as having hit upon this consideration, in going about to prove the Earth to be immoveable, argue not against any other than this *Diurnal Motion*; save onely that *Aristotle* hinteth something in obscure terms against another Motion ascribed to it by an *Ancient*, of which we shall speak in its place.

SAGR. I very well perceive the necessity of your illation; but I meet with a doubt which I know not how to free my self from, and this it is, That *Copernicus* assigning to the Earth another motion beside the *Diurnal*, which, according to the rule even now laid down, ought to be to us, as to appearance, imperceptible in the Earth, but visible in all the rest of the World; me thinks I may necessarily infer, either that he hath manifestly erred in assigning the Earth a motion, to which there appears not a general correspondence in Heaven; or else that if there be such a congruity therein, *Ptolomy* on the other hand hath been deficient in not confuting this, as he hath done the other.

N

SALV.

The motions of the Earth are imperceptible to its inhabitants.

The Earth can have no other motions, than those which to us appear common to all the rest of the Universe, the Earth excepted. The Diurnal Motion, seemeth common to all the Universe, save onely the Earth excepted.

Aristotle and Ptolomy argue against the Diurnal Motion attributed to the Earth.

SALV. You have good cause for your doubt : and when we come to treat of the other Motion, you shall see how far *Copernicus* excelled *Ptolomey* in clearness and sublimity of wit, in that he saw what the other did not, I mean the admirable harmony wherein that Motion agreed with all the other Cœlestial Bodies. But for the present we will suspend this particular, and return to our first consideration ; touching which I will proceed to propose (beginning with things more general) those reasons which seem to favour the mobility of the Earth, and then wait the answers which *Simplicius* shall make thereto. And first, if we consider onely the immense magnitude of the Starry Sphere; compared to the smallness of the Terrestrial Globe, contained therein so many millions of times ; and moreover weigh the velocity of the motion which must in a day and night make an entire revolution thereof, I cannot perswade my self, that there is any man who believes it more reasonable and credible, that the Cœlestial Sphere turneth round, and the Terrestrial Globe stands still.

Why the diurnal motion more probably should belong to the Earth, than to the rest of the Universe.

SAGR. If from the universality of effects, which may in nature have dependence upon such like motions, there should indifferently follow all the same consequences to an hair, aswell in one *Hypothesis* as in the other ; yet I for my part, as to my first and general apprehension, would esteem, that he which should hold it more rational to make the whole Universe move, and thereby to save the Earths mobility, is more unreasonable than he that being got to the top of your Turret, should desire, to the end onely that he might behold the City, and the Fields about it, that the whole Country might turn round, that so he might not be put to the trouble to stir his head. And yet doubtless the advantages would be many and great which the *Copernican Hypothesis* is attended with, above those of the *Ptolomaique*, which in my opinion resembleth, nay surpasseth that other folly ; so that all this makes me think that far more probable than this. But haply *Aristotle*, *Ptolomey*, and *Simplicius* may find the advantages of their Systeme, which they would do well to communicate to us also, if any such there be ; or else declare to me, that there neither are or can be any such things.

SALV. For my part, as I have not been able, as much as I have thought upon it, to find any diversity therein ; so I think I have found, that no such diversity can be in them : in so much that I esteem it to no purpose to seek farther after it. Therefore observe : Motion is so far Motion, and as Motion operateth, by how far it hath relation to things which want Motion : but in those things which all equally partake thereof it hath nothing to do, and is as if it never were. And thus the Merchandises with which a ship is laden, so far move, by how far leaving London, they pass by

Motion, as to the things that equally move thereby, is as if it never were, & so far operates as it hath relation to things deprived of motion.

by France, Spain, Italy, and sail to Aleppo, which London, France, Spain &c. stand still, not moving with the ship : but as to the Chests, Bales and other Parcels, wherewith the ship is stow'd and laden; and in respect of the ship it self, the Motion from London to Syria is as much as nothing ; and nothing-altereth the relation which is between them : and this, because it is common to all, and is participated by all alike : and of the Cargo which is in the ship, if a Bale were romag'd from a Chest but one inch onely, this alone would be in that Cargo, a greater Motion in respect of the Chest, than the whole Voyage of above three thousand miles, made by them as they were stived together.

SIMP. This Doctrine is good, sound, and altogether Peripatetick.

SALV. I hold it to be much more aptient : and suspect that Aristotle in receiving it from some good School, did not fully understand it, and that therefore, having delivered it with some alteration, it hath been an occasion of confusion amongst those, who would defend whatever he saith. And when he writ, that whatsoever moveth, doth move upon something immoveable, I suppose that he equivocated, and meant, that whatever moveth, moveth in respect to something immoveable ; which proposition admitteth no doubt, and the other many.

SAGR. Pray you make no digression, but proceed in the dissertation you began.

SALV. It being therefore manifest, that the motion which is common to many moveables, is idle, and as it were, null as to the relation of those moveables between themselves, because that among themselves they have made no change : and that it is operative onely in the relation that those moveables have to other things, which want that motion, among which the habitude is changed : and we having divided the Universe into two parts, one of which is necessarily moveable, and the other immoveable ; for the obtaining of whatsoever may depend upon, or be required from such a motion, it may as well be done by making the Earth alone, as by making all the rest of the World to move : for that the operation of such a motion consists in nothing else, save in the relation or habitude which is between the Cœlestial Bodies, and the Earth, the which relation is all that is changed. Now if for the obtaining of the same effect *ad unguem*, it be all one whether the Earth alone moveth, the rest of the Universe standing still ; or that, the Earth onely standing still, the whole Universe moveth with one and the same motion ; who would believe, that Nature (which by common consent, doth not that by many things, which may be done by few) hath chosen to make an innumerable number of most vast bodies move, and that with an unconceivable

N 2 velocity;

A proposition taken by Aristotle from the Ancients, but somewhat altered by him.

The first discourse to prove that the diurnal motion belongs to the Earth.

Nature never doth that by many things, which may be done by a few.

velocity, to perform that, which might be done by the moderate motion of one alone about its own Centre?

SIMPL. I do not well understand, how this grand motion signifieth nothing as to the Sun, as to the Moon, as to the other Planets, and as to the innumerable multitude of fixed stars; or why you should say that it is to no purpose for the Sun to pass from one Meridian to another; to rise above this Horizon, to set beneath that other; to make it one while day, another while night; the like variations are made by the Moon, the other Planets, and the fixed stars themselves.

The diurnal motion causeth no mutation amongst the Cœlestial Bodies, but all changes have relation to the Earth.

SALV. All these alterations instanced by you, are nothing, save onely in relation to the Earth: and that this is true, do but imagine the Earth to move, and there will be no such thing in the World as the rising or setting of the Sun or Moon, nor Horizons, nor Meridians, nor days, nor nights; nor, in a word, will such a motion cause any mutation between the Moon and Sun, or any other star whatsoever, whether fixed or erratick; but all these changes have relation to the Earth: which all do yet in sum import no other than as if the Sun should shew it self now to China, anon to Persia, then to Egypt, Greece, France, Spain, America, &c. and the like holdeth in the Moon, and the rest of the Cœlestial Bodies: which self same effect falls out exactly in the same manner, if, without troubling to great a part of the Universe, the Terrestrial Globe be made to revolve in it self. But we will augment the difficulty by the addition of this other, which is a very great one, namely, that if you will ascribe this Great Motion to Heaven, you must of necessity make it contrary to the particular motion of all the Orbs of the Planets, each of which without controversie hath its peculiar motion from the West towards the East, and this but very easie and moderate: and then you make them to be hurried to the contrary part, i. e. from East to West, by this most furious diurnal motion: whereas, on the contrary, making the Earth to move in it self, the contrariety of motions is taken away, and the onely motion from West to East is accommodated to all appearances, and exactly satisfieth every Phenomenon.

A second confirmation that the diurnal motion belongs to the Earth.

Circular motions are not contrary, according to Aristotle.

SIMPL. As to the contrariety of Motions it would import little, for Aristotle demonstrateth, that circular motions, are not contrary to one another; and that theirs cannot be truly called contrariety.

SALV. Doth Aristotle demonstrate this, or doth he not rather barely affirm it, as serving to some certain design of his? If contraries be those things, that destroy one another, as he himself affirmeth, I do not see how two moveables that encounter each other in a circular line, should lesse prejudice one another, than if they interfered in a right line.

SAGR.

DIALOGUE. II.

101

SAGR. Hold a little, I pray you. Tell me *Simplicius*, when two Knights encounter each other, tilting in open field, or when two whole Squadrons, or two Fleets at Sea, make up to grapple, and are broken and sunk, do you call these encounters contrary to one another?

SIMPL. Yes, we say they are contrary.

SAGR. How then, is there no contrariety in circular motions. These motions, being made upon the superficies of the Earth or Water, which are, as you know, spherical, come to be circular. Can you tell, *Simplicius*, which those circular motions be; that are not contrary to each other? They are (if I mistake not) those of two circles, which touching one another without, one thereof being turn'd round, naturally maketh the other move the contrary way; but if one of them shall be within the other, it is impossible that their motion being made towards different points, they should not juggle one another.

SALV. But be they contrary, or not contrary, these are but alterations of words; and I know, that upon the matter, it would be far more proper and agreeable with Nature, if we could salve all with one motion onely, than to introduce two that are (if you will not call them contrary) opposite; yet do I not censure this introduction (of contrary motions) as impossible; nor pretend I from the denial thereof, to inferre a necessary Demonstration, but onely a greater probability, of the other. A third reason which maketh the *Ptolomaique Hypothesis* lesse probable is, that it most unreasonably confoundeth the order, which we assuredly see to be amongst those Cœlestial Bodies; the circumgyration of which is not questionable, but most certain. And that Order is, that according as an Orb is greater, it finisheth its revolution in a longer time, and the lesser, in shorter. And thus *Saturn* describing a greater Circle than all the other Planets, compleateth the same in thirty yeares: *Jupiter* finisheth his; that is lesse, in twelve yeares: *Mars* in two: The Moon runneth thorow hers, so much lesse than the rest, in a Moneth onely. Nor do we lesse sensibly see that of the *Medicean Stars*, which is nearest to *Jupiter*, to make its revolution in a very short time, that is, in four and forty hours, or thereabouts, the next to that in three dayes and an half, the third in seven dayes, and the most remote in sixteen. And this rate holdeth well enough, nor will it at all alter, whilest we assign the motion of 24 hours to the Terrestrial Globe, for it to move round its own center in that time; but if you would have the Earth immoveable, it is necessary, that when you have past from the short period of the Moon, to the others successively bigger, until you come to that of *Mars* in two yeares, and from thence to that of the bigger Sphere of *Jupiter* in twelve yeares, and from

* As you see in a Mill, wherein the implicated cogs set the wheels on moving.

A third confirmation of the same Doctrine.

The greater Orbs make their conversions in greater times.

The times of the Medicean Planets conversions.

*The motion of
24 hours ascribed
to the highest
Sphere disorders
the period of the
inferiour.*

*The fourth Con-
firmation.*

*Great disparity
amongst the moti-
ons of the particu-
lar fixed stars, if
their Sphere be
moveable.*

*The fifth Con-
firmation.*

*The motions of
the fixed stars
would accelerate
and grow slow in
divers times, if the
starry Sphere were
moveable.*

*The sixth Con-
firmation.*

from this to the other yet bigger of *Saturn*, whose period is of thirty years, it is necessary, I say, that you passe to another Sphere incomparably greater still than that, and make this to accomplish an entire revolution in twenty four hours. And this yet is the least disorder that can follow. For if any one should passe from the Sphere of *Saturn* to the Starry Orb, and make it so much bigger than that of *Saturn*, as proportion would require, in respect of its very slow motion, of many thousands of years, then it must needs be a *Salt* much more absurd, to skip from this to another bigger, and to make it convertible in twenty four hours. But the motion of the Earth being granted, the order of the periods will be exactly observed, and from the very slow Sphere of *Saturn*, we come to the fixed Stars, which are wholly immoveable, and so avoid a fourth difficulty, which we must of necessity admit, if the Starry Sphere be supposed moveable, and that is the immense disparity between the motions of those stars themselves; of which some would come to move most swiftly in most vast circles, others most slowly in circles very small, according as those or these should be found nearer, or more remote from the Poles, which still is accompanied with an inconvenience, as well because we see those, of whose motion there is no question to be made, to move all in very immense circles; as also, because it seems to be an act done with no good consideration, to constitute bodies, that are designed to move circularly, at immense distances from the centre, and afterwards to make them move in very small circles. And not onely the magnitudes of the circles, and consequently the velocity of the motions of these Stars; shall be most different from the circles and motions of those others, but (which shall be the fifth inconvenience) the self-same Stars shall successively vary its circles and velocities: For that those, which two thousand years since were in the Equinoctial, and consequently did with their motion describe very vast circles, being in our dayes many degrees distant from thence, must of necessity become more slow of motion, and be reduced to move in lesser circles, and it is not altogether impossible but that a time may come, in which some of them which in aforetime had continually moved, shall be reduced by uniting with the Pole, to a state of rest, and then after some time of cessation, shall return to their motion again; whereas the other Stars, touching whose motion none stand in doubt, do all describe, as hath been said, the great circle of their Orb, and in that maintain themselves without any variation. The absurdity is farther enlarged (which let be the sixth inconvenience) to him that more seriously examineth the thing, in that no thought can comprehend what ought to be the solidity of that immense Sphere, whose depth so steadfastly holdeth

holdeth fast such a multitude of Stars, which without ever changing site among themselves, are with so much concord carried about, with so great disparity of motions. Or else, supposing the Heavens to be fluid, as we are with more reason to believe, so as that every Star wandereth to and fro in it, by wayes of its own; what rules shall regulate their motions, and to what purpose, so, as that being beheld from the Earth, they appear as if they were made by one onely Sphere? It is my opinion, that they might so much more easily do that, and in a more commodious manner, by being constituted immoveable, than by being made errant, by how much more facile it is to number the quarries in the Pavement of a *Piazza*, than the rout of boyes which run up and down upon them. And lastly, which is the seventh instance, if we attribute the Diurnal Motion to the highest Heaven, it must be constituted of such a force and efficacy, as to carry along with it the innumerable multitude of fixed Stars, Bodies all of vast magnitude, and far bigger than the Earth; and moreover all the Spheres of the Planets; notwithstanding that both these and those of their own nature move the contrary way. And besides all this, it must be granted, that also the Element of Fire, and the greater part of the Air, are likewise forcibly hurried along with the rest, and that the sole little Globe of the Earth pertinaciously stands still, and unmoved against such an impulse; a thing, which in my thinking, is very difficult; nor can I see how the Earth, a pendent body, and equilibrated upon its centre, exposed indifferently to either motion or rest, and environed with a liquid ambient, should not yield also as the rest, and be carried about. But we find none of these obstacles in making the Earth to move; a small body, and insensible, compared to the Universe, and therefore unable to offer it any violence.

SAGR. I find my fancy disturbed with certain conjectures so confusedly sprung from your later discourses; that, if I would be enabled to apply my self with attention to what followeth, I must of necessity attempt whether I can better methodize them, and gather thence their true construction; if haply any can be made of them; and peradventure, the proceeding by interrogations may help me the more easily to expresse my self. Therefore I demand first of *Simplicius*, whether he believeth, that divers motions may naturally agree to one and the same moveable body, or else that it be requisite its natural and proper motion be onely one.

SIMPLICIUS. To one single moveable, there can naturally agree but one sole motion, and no more; the rest all happen accidentally and by participation; like as to him that walketh upon the Deck of a Ship, his proper motion is that of his walk, his motion by participation that which carrieth him to his Port, whither he would

The Seventh Confirmation.

The Earth a pendent Body, and equilibrated in a fluid Medium seems unable to resist the rapture of the Diurnal Motion.

A single moveable hath but one natural motion, and all the rest are by participation.

would never with his walking have arrived, if the Ship with its motion had not waisted him thither.

SAGR. Tell me secondly. That motion, which is communicated to any moveable by participation, whilst it moveth by it self, with another motion different from the participated, is it necessary, that it do reside in some certain subject by it self, or else can it subsist in nature alone, without other support.

*Motion cannot
be made without
its moveable sub-
ject.*

SIMPL. Aristotle giveth you an answer to all these questions, and tels you, that as of one sole moveable the motion is but one; so of one sole motion the moveable is but one; and consequently, that without the inherence in its subject, no motion can either subsist, or be imagined.

SAGR. I would have you tell me in the third place, whether you beblieve that the Moon and the other Planets and Cœlestial bodies, have their proper motions, and what they are.

SIMPL. They have so, and they be those according to which they run through the Zodiack, the Moon in a Moneth, the Sun in a Year, Mars in two, the Starry Sphere in those so many thousand. And these are their proper, or natural motions.

SAGR. But that motion wherewith I see the fixed Stars, and with them all the Planets go unitedly from East to West, and return round to the East again in twenty four hours, how doth it agree with them?

SIMPL. It suiteth with them by participation.

SAGR. This then resides not in them, and not residing in them; nor being able to subsist without some subject in which it is resident, it must of force be the proper and natural motion of some other Sphere.

SIMPL. For this purpose Astronomers, and Philosophers have found another high Sphere, above all the rest, without Stars, to which Nature agreeth the Diurnal Motion; and this they call the *Primum mobile*; the which carrieth along with it all the inferiour Spheres, contributing and imparting its motion to them.

SAGR. But when, without introducing other Spheres unknown and hugely vast, without other motions or communicated raptures, with leaving to each Sphere its sole and simple motion, without intermixing contrary motions, but making all turn one way, as it is necessary that they do, depending all upon one sole principle, all things proceed orderly, and correspond with most perfect harmony, why do we reject this *Phænomenon*, and give our assent to those prodigious and laborious conditions?

SIMPL. The difficulty lyeth in finding out this so natural and expeditious way.

SAGR.

SAGE. In my judgment this is found. Make the Earth the *Primum mobile*, that is, make it turn round its own *axis* in twenty four hours, and towards the same point with all the other Spheres; and without participating this same motion to any other Planet or Star, all shall have their risings, settings, and in a word, all their other appearances.

SIMPL. The business is, to be able to make the Earth move without athousand inconveniences.

SALV. All the inconveniences shall be removed as fast as you propound them: and the things spoken hitherto are onely the primary and more general inducements which give us to believe that the diurnal conversion may not altogether without probability be applyed to the Earth, rather than to all the rest of the Universe: the which inducements I impose not upon you as inviolable Axioms, but as hints, which carry with them somewhat of likelihood. And in regard I know very well, that one sole experiment, or concludent demonstration, produced on the contrary part, sufficeth to batter to the ground these and a thousand other probable Arguments; therefore it is not fit to stay here, but proceed forwards and hear what *Simplicius* answereth; and what greater probabilities, or stronger arguments he alledgeth on the contrary.

SIMPL. I will first say something in general upon all these considerations together, and then I will descend to some particulars. It seems that you universally bottom all you say upon the greater simplicity and facility of producing the same effects, whilst you hold, that as to the causing of them, the motion of the Earth alone, serveth as well as that of all the rest of the World, the Earth deducted: but as to the operations, you esteem that much easier than this. To which I reply, that I am also of the same opinion, so long as I regard my own not onely finite, but feeble power; but having a respect to the strength of the *Mover*, which is infinite, its no lesse easie to move the Universe, than the Earth, yea than a straw. And if his power be infinite, why should he not rather exercise a greater part thereof than a lesse? Therefore, I hold that your discourse in general is not convincing.

SALV. If I had at any time said, that the Universe moved not for want of power in the *Mover*, I should have erred, and your reproof would have been seasonable; and I grant you, that to an infinite power, it is as easie to move an hundred thousand, as one. But that which I did say, concerns not the *Mover*, but onely hath respect to the *Moveables*; and in them, not onely to their resistance, which doubtlesse is lesser in the Earth, than in the Universe; but to the many other particulars, but even now considered. As to what you say in the next place, that of an infinite power it is better to exercise a great part than a small: I answer,

One single experiment, or sound demonstration battereth down all arguments merely probable.

Of an infinite power one would think a greater part should rather be employ'd than a lesse.

Of infinity, one part is no bigger than another, although they are comparatively unequal.

swer, that of infinite one part is not greater than another, since both are infinite; nor can it be said, that of the infinite number, an hundred thousand is a greater part than two, though that be fifty thousand times greater than this; and if to the moving of the Universe there be required a finite power, though very great in comparison of that which sufficeth to move the Earth onely; yet is there not implied therein a greater part of the infinite power, nor is that part lesse infinite which remaineth unemploy'd. So that to apply unto a particular effect, a little more, or a little lesse power, importeth nothing; besides that the operation of such vertue, hath not for its bound or end the Diurnal Motion onely; but there are several other motions in the World, which we know of; and many others there may be, that are to us unknown. Therefore if we respect the Moveables, and granting it as out of question, that it is a shorter and easier way to move the Earth, than the Universe; and moreover, having an eye to the so many other abbreviations, and facilities that onely this way are to be obtained; an infallible Maxime of Aristotle, which he teacheth us, that, *frustra fit per plura, quod potest fieri per pauciora*, rendereth it more probable that the Diurnal Motion belongs to the Earth alone, than to the Universe, the Earth subducted.

SIMPL. In reciting that Axiom, you have omitted a small clause, which importeth as much as all the rest, especially in our case, that is to say, the words *æque bene*. It is requisite therefore to examine whether this Hypothesis doth equally well satisfy in all particulars, as the other.

In the Axiome Frustra fit per plura, &c. the addition of æque bene, is superfluous.

SALV. The knowledg whether both these positions do *æque bene*, satisfy, may be comprehended from the particular examination of the appearances which they are to satisfy; for hitherto we have discoursed; and will continue to argue *ex hypothesi*; namely, supposing, that as to the satisfaction of the appearances, both the assumptions are equally accomodated. As to the clause which you say was omitted by me, I have more reason to suspect that it was superfluously inserted by you. For the expression *æque bene*, is a relative that necessarily requireth two terms at least; for a thing cannot have relation to its self, nor do we say, *v. gr.* rest to be equally good, as rest. And because, when we say, *that is done in vain by many means, which may be done with fewer*, we mean; that that which is to be done, ought to be the same thing, not two different ones; and because the same thing cannot be said to be done as well as its self; therefore, the addition of the Phrase *æque bene* is superfluous, and a relation, that hath but one term onely.

SAGR. Unlesse you will have the same befall us, as did yesterday, let us return to our matter in hand; and let *Simplicius* begin

gin to produce those difficulties that seem in his opinion, to thwart this new disposition of the World.

SIMPL. That disposition is not new, but very old; and that you may see it is so, *Aristotle* confuteth it; and his confutations are these: "First if the Earth moveth either in it self about its own Centre, or in an Excentrick Circle, it is necessary that that same motion be violent; for it is not its natural motion, for if it were, each of its parts would partake thereof; but each of them moveth in a right line towards its Centre. It being therefore violent and pternatural, it could never be perpetual: But the order of the World is perpetual. Therefore, &c. Secondly, all the other moveables that move circularly, seem to stay behind, and to move with more than one motion, the *Primum Mobile* excepted: Whence it would be necessary that the Earth also do move with two motions; and if that should be so, it would inevitably follow; that mutations should be made in the Fixed Stars, the which none do perceive; nay without any variation, the same Stars alwayes rise from towards the same places, and in the same places do set. Thirdly, the motion of the parts is the same with that of the whole, and naturally tendeth towards the Centre of the Universe; and for the same cause rest, being arrived thither. He thereupon moves the question whether the motion of the parts hath a tendency to the centre of the Universe, or to the centre of the Earth; and concluding that it goeth by proper instinct to the centre of the Universe, and *per accidente* to that of the Earth; of which point we largely discoursed yesterday. He lastly confirmeth the same with a fourth argument taken from the experiment of grave bodies, which falling from on high, descend perpendicularly unto the Earths surface; and in the same manner *Projections* shot perpendicularly upwards, do by the same lines return perpendicularly down again, though they were shot to a very great height. All which arguments necessarily prove their motion to be towards the Centre of the Earth, which without moving at all waits for, and receiveth them. He intimateth in the last place that the Astronomers alledg other reasons in confirmation of the same conclusions, I mean of the Earths being in the Centre of the Universe, and immoveable; and instanceth onely in one of them, to wit, that all the *Phænomena* or appearances that are seen in the motions of the Stars, perfectly agree with the position of the Earth in the Centre; which would not be so, were the Earth seated otherwise. The rest produced by *Ptolomy* and the other Astronomers, I can give you now if you please, or after you have spoken what you have to say in answer to these of *Aristotle*.

SALV. The arguments which are brought upon this occasion are

Aristotles Arguments for the Earths quiescence.

* *Resisto indietzo*, which is meant here of that motion which a bowl makes when its born by its byas to one side or other, and so hindered in its direct motion.

Two kinds of Arguments touching the Earths motion or rest.

Arguments of Ptolomy and Tycho, and other persons, over and above those of Aristotle.

The first argument taken from grave bodies falling from on high to the ground.

Which is confirmed by the experiment of a body let fall from the round top of a Ship.

That is, at the foot of the Mast, upon the upper deck.

The second argument taken from a Projection shot very high.

The third argument taken from the shots of a Cannon, towards the East, and towards the West.

are of two kinds: some have respect to the accidents Terrestrial, without any relation to the Stars, and others are taken from the *Phænomena* and observations of things Cœlestial. The arguments of *Aristotle* are for the most part taken from things neer at hand, and he leaveth the others to *Astronomers*; and therefore it is the best way, if you like of it, to examine these taken from experiments touching the Earth, and then proceed to those of the other kind. And because *Ptolomy*, *Tycho*, and the other *Astronomers* and *Philosophers*, besides the arguments of *Aristotle* by them assumed, confirmed, and made good, do produce certain others; we will put them all together, that so we may not answer twice to the same, or the like objections. Therefore *Simplicius*, choose whether you will recite them your self, or cause me to ease you of this task, for I am ready to serve you.

SIMPL. It is better that you quote them, because, as having taken more pains in the study of them, you can produce them with more readinesse, and in greater number.

SALV. All, for the strongest reason, alledge that of grave bodies, which falling downwards from on high, move by a right line, that is perpendicular to the surface of the Earth, an argument which is held undeniably to prove that the Earth is immoveable: for in case it should have the diurnal motion, a Tower, from the top of which a stone is let fall, being carried along by the conversion of the Earth, in the time that the stone spends in falling, would be transported many hundred yards Eastward, and so far distant from the Towers foot would the stone come to ground. The which effect they back with another experiment; to wit, by letting a bullet of lead fall from the round top of a Ship, that lieth at anchor, and observing the mark it makes where it lights, which they find to be neer the * partners of the Mast; but if the same bullet be let fall from the same place when the ship is under sail, it shall light as far from the former place, as the ship hath run in the time of the leads descent; and this for no other reason, than because the natural motion of the ball being at liberty is by a right line towards the centre of the Earth. They fortifie this argument with the experiment of a projection shot on high at a very great distance; as for example, a ball sent out of a Cannon, erected perpendicular to the horizon, the which spendeth so much time in ascending and falling, that in our parallel the Cannon and we both should be carried by the Earth many miles towards the East, so that the ball in its return could never come neer the Peece, but would fall as far West, as the Earth had run East. They againe adde a third, and very evident experiment, *scilicet*, that shooting a bullet point blank (or as Gunners say, neither above nor under metal) out of a Culverin towards the East, and afterwards another, with

with the same charge, and at the same elevation or disport towards the West, the range towards the West should be very much greater than the other towards the East: for that whilst the ball goeth Westward, and the Peece is carried along by the Earth Eastward, the ball will fall from the Peece as far distant as is the aggregate of the two motions, one made by it self towards the West; and the other by the Peece carried about by the Earth towards the East; and on the contrary, from the range of the ball shot Eastward you are to subtract the space the Peece moved, being carried after it. Now suppose, for example, that the range of the ball shot West were five miles, and that the Earth in the same parallel and in the time of the Balls ranging should remove three miles, the Ball in this case would fall eight miles distant from the Culverin, namely, its own five Westward, and the Culverins three miles Eastward: but the range of the shot towards the East would be but two miles long, for so much is the remainder, after you have subtracted from the five miles of the range, the three miles which the Peece had moved towards the same part. But experience sheweth the Ranges to be equal, therefore the Culverin, and consequently the Earth are immoveable. And the stability of the Earth is no less confirmed by two other shots made North and South; for they would never hit the mark, but the Ranges would be alwayes wide; or towards the West, by meanes of the remove the mark would make, being carried along with the Earth towards the East, whilst the ball is flying. And not onely shots made by the Meridians, but also those aimed East or West would prove uncertain; for those aim'd East would be too high, and those directed West too low, although they were shot point blank, as I said. For the Range of the Ball in both the shots being made by the Tangent, that is, by a line parallel to the Horizon, and being that in the diurnal motion, if it be of the Earth, the Horizon goeth continually descending towards the East, and rising from the West (therefore the Oriental Stars seem to rise, and the Occidental to decline) so that the Oriental mark would descend below the aime, and thereupon the shot would fly too high, and the ascending of the Western mark would make the shot aimed that way range too low; so that the Peece would never carry true towards any point; and for that experience telleth us the contrary, it is requisite to say, that the Earth is immoveable.

SIMPL. These are solid reasons, and such as I believe no man can answer.

SALV. Perhaps they are new to you?

SIMPL. Really they are; and now I see with how many admirable experiments Nature is pleased to favour us, wherewith to assist us in the knowledge of the Truth. Oh! how exactly one truth

This argument is confirmed by two shots towards the South and towards the North.

And it is likewise confirmed by two shots towards the East, and towards the West.

truth agreeth with another, and all conspire to render each other inexpugnable !

SAGR. What pity it is that Guns were not used in *Aristotles* age, he would with help of them have easily battered down ignorance, and spoke without hesitation of these mundane points.

SALV. I am very glad that these reasons are new unto you, that so you may not rest in the opinion of the major part of *Peripateticks*, who believe, that if any one forsakes the Doctrine of *Aristotle*, it is because they did not understand or rightly apprehend his demonstrations. But you may expect to hear of other Novelties, and you shall see the followers of this new Systeme produce against themselves observations, experiences, and reasons of farre greater force than those alledged by *Aristotle*, *Ptolomy*, and other opposers of the same conclusions, and by this means you shall come to ascertain your self that they were not induced through want of knowledge or experience to follow that opinion.

SAGR. It is requisite that upon this occasion I relate unto you some accidents that befell me, so soon as I first began to hear speak of this new doctrine. Being very young, and having scarcely finished my course of Philosophy, which I left off, as being set upon other employments, there chanced to come into these parts a certain Foreigner of *Rostock*, whose name, as I remember, was *Christianus Vurstinius*, a follower of *Copernicus*, who in an *Academy* made two or three Lectures upon this point, to whom many flock't as Auditors ; but I thinking they went more for the novelty of the subject than otherwise, did not go to hear him : for I had concluded with my self that that opinion could be no other than a solemn madness. And questioning some of those who had been there, I perceived they all made a jest thereof, except one, who told me that the business was not altogether to be laugh't at, and because this man was reputed by me to be very intelligent and wary, I repented that I was not there, and began from that time forward as oft as I met with any one of the *Copernican* persuasion, to demand of them, if they had been alwayes of the same judgment; and of as many as I examined, I found not so much as one, who told me not that he had been a long time of the contrary opinion, but to have changed it for this, as convinced by the strength of the reasons proving the same : and afterwards questioning them, one by one, to see whether they were well possesst of the reasons of the other side; I found them all to be very ready and perfect in them ; so that I could not truly say, that they had took up this opinion out of ignorance, vanity, or to shew the acutenesse of their wits. On the contrary, of as many of the *Peripateticks* and *Ptolomeans* as I have asked (and out of curiosity I have talked with many) what pains they had taken in the Book of *Copernicus*, I found very few

Copernicus his followers are not moved through ignorance of the arguments on the other part.

Christianus Vurstinius read certain Lectures touching the opinion of Copernicus, & what ensued thereupon.

The followers of Copernicus were all first against that opinion, but the Seditors of Aristotle & Ptolomy, were never of the other side.

few that had so much as superficially perused it; but of those whom, I thought, had understood the same, not one; and moreover, I have enquired amongst the followers of the *Peripatetick* Doctrine, if ever any of them had held the contrary opinion, and likewise found none that had. Whereupon considering that there was no man who followed the opinion of *Copernicus*, that had not been first on the contrary side, and that was not very well acquainted with the reasons of *Aristotle* and *Ptolomy*; and, on the contrary, that there is not one of the followers of *Ptolomy* that had ever been of the judgment of *Copernicus*, and had left that, to imbrace this of *Aristotle*, considering, I say, these things, I began to think, that one, who leaveth an opinion imbued with his milk, and followed by very many, to take up another owned by very few, and denied by all the Schools, and that really seems a very great Paradox, must needs have been moved, not to say forced, by more powerful reasons. For this cause, I am become very curious to dive, as they say, into the bottom of this businesse, and account it my great good fortune that I have met you two, from whom I may without any trouble, hear all that hath been, and, haply, can be said on this argument, assuring my self that the strength of your reasons will resolve all scruples, and bring me to a certainty in this subject.

SIMPL. But its possible your opinion and hopes may be disappointed, and that you may find your selves more at a losse in the end than you was at first.

SAGR. I am very confident that this can in no wise befall me.

SIMPL. And why not? I have a manifest example in my self, that the farther I go, the more I am confounded.

SAGR. This is a sign that those reasons that hitherto seemed concluding unto you, and assured you in the truth of your opinion, begin to change countenance in your mind, and to let you by degrees, if not imbrace, at least look towards the contrary tenent; but I, that have been hitherto indifferent, do greatly hope to acquire rest and satisfaction by our future discourses, and you will not deny but I may, if you please but to hear what perswadeth me to this expectation.

SIMPL. I will gladly hearken to the same, and should be no lesse glad that the like effect might be wrought in me.

SAGR. Favour me therefore with answering to what I shall ask you. And first, tell me, *Simplicius*, is not the conclusion, which we seek the truth of, Whether we ought to hold with *Aristotle* and *Ptolomy*, that the Earth onely abiding without motion in the Centre of the Universe, the Cœlestial bodies all move, or else, Whether the Starry Sphere and the Sun standing still in the Centre,

the

the Earth is without the same, and owner of all those motions that in our seeming belong to the Sun and fixed Stars?

SIMPL. These are the conclusions which are in dispute.

SAGR. And these two conclusions, are they not of such a nature, that one of them must necessarily be true, and the other false?

SIMPL. They are so. We are in a *Dilemma*, one part of which must of necessity be true, and the other untrue; for between Motion and Rest, which are contradictories, there cannot be instanced a third, so as that one cannot say the Earth moves not, nor stands still; the Sun and Stars do not move, and yet stand not still.

SAGR. The Earth, the Sun, and Stars, what things are they in nature? are they petite things not worth our notice, or grand and worthy of consideration?

SIMPL. They are principal, noble, integral bodies of the Universe, most vast and considerable.

SAGR. And Motion, and Rest, what accidents are they in Nature?

*Motion and rest
principal accidents
in nature.*

SIMPL. So great and principal, that Nature her self is defined by them.

SAGR. So that moving eternally, and the being wholly immoveable are two conditions very considerable in Nature, and indicate very great diversity; and especially when ascribed to the principal bodies of the Universe, from which can ensue none but very different events.

SIMPL. Yea doubtlesse.

SAGR. Now answer me to another point. Do you believe that in *Logick*, *Rhetorick*, the *Physicks*, *Metaphysicks*, *Mathematicks*, and finally, in the universality of Disputations there are arguments sufficient to perswade and demonstrate to a person the fallacious, no lesse then the true conclusions?

*Truths cannot
be demonstrated,
as Truths are.*

*For proof of true
conclusions, many
solid arguments
may be produced,
but to prove a fal-
sity, none.*

SIMPL. No Sir; rather I am very confident and certain, that for the proving of a true and necessary conclusion, there are in nature not onely one, but many very powerfull demonstrations: and that one may discusse and handle the same divers and sundry wayes, without ever falling into any absurdity; and that the more any Sophist would disturb and muddy it, the more clear would its certainty appear: And that on the contrary to make a false position passe for true, and to perswade the belief thereof, there cannot be any thing produced but fallacies, Sophisms, Paralogismes, Equivocations, and Discourses vain, inconsistent, and full of repugnances and contradictions.

SAGR. Now if eternal motion, and eternal rest be so principal accidents of Nature, and so different; that there can depend on them only most different consequences, and especially when applied

applied to the Sun, and to the Earth, so vast and famous bodies of the Universe; and it being, moreover, impossible, that one of two contradictory Propositions, should not be true, and the other false; and that for proof of the false one, any thing can be produced but fallacies; but the true one being perswadeable by all kind of concluding and demonstrative arguments, why should you think that he, of you two, who shall be so fortunate as to maintain the true Proposition ought not to perswade me? You must suppose me to be of a stupid wit, perverse judgment, dull mind and intellect, and of a blind reason; that I should not be able to distinguish light from darknesse, jewels from coals, or truth from falshood.

SIMP. I tell you now, and have told you upon other occasions, that the best Master to teach us how to discern Sophismes, Paralogismes, and other fallacies, was *Aristotle*, who in this particular can never be deceived.

SAGRED. You insist upon *Aristotle*, who cannot speak. Yet I tell you, that if *Aristotle* were here, he would either yield himself to be perswaded by us, or refuting our arguments, convince us by better of his own. And you your self, when you heard the experiments of the Suns related, did you not acknowledg and admire them, and confesse them more concludent than those of *Aristotle*? Yet nevertheless I cannot perceive that *Salviatus*, who hath produced them, examined them, and with exquisite care scan'd them, doth confesse himself perswaded by them; no nor by others of greater force, which he intimated that he was about to give us an account of. And I know not on what grounds you should censure Nature, as one that for many Ages hath been lazie, and forgetful to produce speculative wits; and that knoweth not how to make more such, unlesse they be such kind of men as slavishly giving up their judgments to *Aristotle*, do understand with his brain, and resent with his senses. But let us hear the residue of those reasons which favour his opinion, that we may thereupon proceed to speak to them; comparing and weighing them in the ballance of impartiality.

SALV. Before I proceed any farther, I must tell *Sagredus*, that in these our Disputations, I personate the *Copernican*, and imitate him, as if I were his *Zany*; but what hath been effected in my private thoughts by these arguments which I seem to alledg in his favour, I would not have you to judg by what I say; whilst I am in the heat of acting my part in the Fable; but after I have laid by my disguise, for you may chance to find me different from what you see me upon the Stage. Now let us go on.

Ptolomy and his followers produce another experiment like to that of the Projections, and it is of things that being separated

Aristotle would either refuse his adversaries arguments, or would alter his opinion.

An argument taken from the Clouds, and from Birds.

P

from

*An argument
taken from the air
which we feel to
beat upon us when
we run a Horse at
full speed.*

*An argument
taken from the
whirling of circu-
lar motion, which
hath a faculty to
extrude and dissi-
pate.*

from the Earth, continue a good space of time in the Air, such as are the Clouds, Birds of flight; and as of them it cannot be said that they are rapt or tranſported by the Earth, having no adheſion thereto; it ſeems not poſſible, that they ſhould be able to keep pace with the velocity thereof; nay it ſhould rather ſeem to us, that they all ſwiftly move towards the Weſt. And if being carried about by the Earth, paſſe our parallel in twenty four hours, which yet is at leaſt ſixteen thouſand miles; how can Birds follow ſuch a courſe or revolution? Whereas on the contrary, we ſee them fly as well towards the Eaſt, as towards the Weſt, or any other part, without any ſenſible difference. Moreover, if when we run a Horſe at his ſpeed, we feel the air beat vehemently againſt our face, what an impetuous blaſt ought we perpetually to feel from the Eaſt; being carried with ſo rapid a courſe againſt the wind? and yet no ſuch effect is perceived. Take another very ingenious argument inferred from the following experiment. The circular motion hath a faculty to extrude and diſſipate from its Centre the parts of the moving body, whenſoever either the motion is not very ſlow, or thoſe parts are not very well faſtened together; and therefore, if v. g. we ſhould turn one of thoſe great wheels very faſt about, wherein one or more men walking, crane up very great weights, as the huge maſſie ſtone, uſed by the Callander for preſſing of Cloaths; or the freighted Barks which being haled on ſhore, are hoisted out of one river into another; in caſe the parts of that ſame Wheel ſo ſwiftly turn'd round, be not very well joyn'd and pin'd together, they would all be ſhattered to pieces; and though many ſtones or other ponderous ſubſtances, ſhould be very faſt bound to its outward Rimme; yet could they not reſiſt the impetuofity, which with great violence would hurl them every way far from the Wheel, and conſequently from its Centre. So that if the Earth did move with ſuch and ſo much greater velocity, what gravity, what tenacity of lime or plaſter would keep together Stones, Buildings, and whole Cities, that they ſhould not be toſt into the Air by ſo precipitous a motion? And both men and beaſts, which are not faſtened to the Earth, how could they reſiſt ſo great an *impetus*? Whereas, on the other ſide, we ſee both theſe, and far leſſe reſiſtances of pebbles, ſands, leaves reſt quietly on the Earth, and to return to it in falling, though with a very ſlow motion. See here, *Simplicius*, the moſt potent arguments, taken, to ſo ſpeak, from things Terreſtrial; there remain thoſe of the other kind, namely, ſuch as have relation to the appearances of Heaven, which reaſons, to confeſſe the truth, tend more to prove the Earth to be in the centre of the Univerſe, and conſequently, to deprive it of the annual motion about the ſame, aſcribed unto it by

by *Copernicus*. Which arguments, as being of somewhat a different nature, may be produced, after we have examined the strength of these already propounded.

SAGR. What say you *Simplicius*? do you think that *Salviatus* is Master of, and knoweth how to unfold the *Ptolomean* and *Aristotelian* arguments? Or do you think that any *Peripatetick* is equally versed in the *Copernican* demonstrations?

SIMPL. Were it not for the high esteem, that the past discourses have begot in me of the learning of *Salviatus*, and of the acutenesse of *Sagredus*, I would by their good leave have gone my way without staying for their answers; it seeming to me a thing impossible, that so palpable experiments should be contradicted; and would, without hearing them farther, confirm my self in my old perswasion; for though I should be made to see that it was erroneous, its being upheld by so many probable reasons, would render it excuseable. And if these are fallacies, what true demonstrations were ever so fair?

SAGR. Yet its good that we hear the responsions of *Salviatus*; which if they be true, must of necessity be more fair, and that by infinite degrees; and those must be deformed, yea most deformed, if the Metaphysical Axiome hold. That true and fair are one and the same thing; as also false and deformed. Therefore *Salviatus* let's no longer lose time.

SALV. The first Argument alledged by *Simplicius*, if I well remember it, was this. The Earth cannot move circularly, because such motion would be violent to the same; and therefore not perpetual: that it is violent, the reason was: Because, that had it been natural, its parts would likewise naturally move round, which is impossible, for that it is natural for the parts thereof to move with a right motion downwards. To this my reply is, that I could gladly wish, that *Aristotle* had more cleerly exprest himself, where he said; That its parts would likewise move circularly; for this moving circularly is to be understood two ways; one is, that every particle or atome separated from its *Whole* would move circularly about its particular centre, describing its small Circulets; the other is, that the whole Globe moving about its centre in twenty four hours, the parts also would turn about the same centre in four and twenty hours. The first would be no lesse an impertinency, than if one should say, that every part of the circumference of a Circle ought to be a Circle; or because that the Earth is Spherical, that therefore every part thereof be a Globe, for so doth the Axiome require. *Eadem est ratio totius, & partium*. But if he took it in the other sense, to wit, that the parts in imitation of the *Whole* should move naturally round the Centre of the whole Globe in twenty four hours, I say, that they do so; and it concerns you,

True and fair
are one and the
same, as also false
and deformed.

The answer to
Aristotles first
argument.

instead of *Aristotle*, to prove that they do not.

SIMPL. This is proved by *Aristotle* in the same place, when he saith, that the natural motion of the parts is the right motion downwards to the centre of the Universe; so that the circular motion cannot naturally agree therewith.

SALV. But do not you see, that those very words carry in them a confutation of this solution?

SIMPL. How? and where?

SALV. Doth not he say that the circular motion of the Earth would be violent? and therefore not eternal? and that this is absurd, for that the order of the World is eternal?

SIMPL. He saith so.

That which is violent, cannot be eternal, and that which cannot be eternal, cannot be natural.

SALV. But if that which is violent cannot be eternal, then by conversion, that which cannot be eternal, cannot be natural: but the motion of the Earth downwards cannot be otherwise eternal; therefore much lesse can it be natural: nor can any other motion be natural to it, save onely that which is eternal. But if we make the Earth move with a circular motion, this may be eternal to it, and to its parts, and therefore natural.

SIMPL. The right motion is most natural to the parts of the Earth, and is to them eternal; nor shall it ever happen that they move not with a right motion, alwayes provided that the impediments be removed.

SALV. You equivocate *Simplicius*; and I will try to free you from the equivoke. Tell me, therefore, do you think that a Ship which should sail from the Strait of *Gibraltar* towards *Palestina* can eternally move towards that Coast? keeping alwayes an equal course?

SIMPL. No doubtlesse.

SALV. And why not?

SIMPL. Because that Voyage is bounded and terminated between the *Herculean* Pillars, and the shore of the *Holy-land*; and the distance being limited, it is past in a finite time, unlesse one by returning back should with a contrary motion begin the same Voyage anew; but this would be an interrupted and no continued motion.

SALV. Very true. But the Navigation from the Strait of *Magalanes* by the *Pacifick* Ocean, the *Moluccha's*, the *Cape di buona Speranza*, and from thence by the same Strait, and then again by the *Pacifick* Ocean, &c. do you believe that it may be perpetuated?

SIMPL. It may; for this being a circumgyration, which returneth about its self, with infinite replications, it may be perpetuated without any interruption.

SALV. A Ship then may in this Voyage continue sailing eternally.

SIMPL.

SIMP. It may, in case the Ship were incorruptible, but the Ship decaying, the Navigation must of necessity come to an end.

SALV. But in the Mediterrane; though the Vessel were incorruptible, yet could she not sail perpetually towards *Palestina*, that Voyage being determined. Two things then are required, to the end a moveable may without intermission move perpetually; the one is, that the motion may of its own nature be indeterminate and infinite; the other, that the moveable be likewise incorruptible and eternal.

SIMP. All this is necessary.

SALV. Therefore, you may see how of your own accord you have confessed it impossible that any moveable should move eternally in a right line, in regard that right motion, whether it be upwards, or downwards, is by you your self bounded by the circumference and centre; so that if a Moveable, as suppose the Earth be eternal, yet forasmuch as the right motion is not of its own nature eternall; but most terminate, it cannot naturally suit with the Earth. Nay, as was said yesterday, *Aristotle* himself is constrained to make the Terrestrial Globe eternally immoveable. When again you say, that the parts of the Earth evermore move downwards, all impediments being removed, you egregiously equivocate; for then, on the other side they must be impeded, contrariet; and forced, if you would have them move; for, when they are once fallen to the ground, they must be violently thrown upwards, that they may a second time fall; and as to the impediments, these only hinder its arrival at the centre; but if there were a Well, that did passe thorow and beyond the centre, yet would not a clod of Earth passe beyond it, unlesse inasmuch as being transported by its impetus, it should passe the same to return thither again, and in the end there to rest. As therefore to the defending, that the motion by a right line doth or can agree naturally neither to the Earth, nor to any other moveable, whilst the Universe retaineth its perfect order, I would have you take no further paines about it, but (unlesse you will grant them the circular motion) your best way will be to defend and maintain their immobility.

SIMP. As to their immoveableness, the arguments of *Aristotle*, and moreover those alledged by your self seem in my opinion necessarily to conclude the same, as yet; and I conceive it will be a hard matter to refute them.

SALV. Come we therefore to the second Argument, which was, That those bodies, which we are assured do move circularly, have more than one motion, unlesse it be the *Primum Mobile*; and therefore, if the Earth did move circularly, it ought to have two motions; from which alterations would follow in the rising and setting of the Fixed Stars: Which effect is not perceived to ensue.

There-

Two things requisite to the end a motion may perpetuate it self; an unlimited space, and an incorruptible moveable.

Right motion cannot be eternal, and consequently cannot be natural to the Earth.

* Terminatissimo.

* By this expression he every where means the preceding Dialogue, or *Giornata*.

The answer to the second Argument.

Therefore, &c. The most proper and genuine answer to this Allegation is contained in the Argument it self; and even *Aristotle* puts it in our mouths, which it is impossible, *Simplicius*, that you should not have seen.

SIMPL. I neither have seen it, nor do I yet apprehend it.

SALV. This cannot be, sure, the thing is so very plain.

SIMPL. I will with your leave, cast an eye upon the *Text*.

SAGR. We will command the *Text* to be brought forthwith.

SIMPL. I alwayes carry it about with me: See here it is; and I know the place perfectly well, which is in *lib. 2. De Cælo, cap. 16.* Here it is, *Text 97. Preterea omnia, quæ feruntur latione circulari subdeficere videntur, ac moveri pluribus una latione, præter primam Sphæram; quare & Terram necessariam est, siue circa medium, siue in medio posita feratur, duabus moveri lationibus. Si autem hoc acciderit, necessariam est fieri mutationes, ac conversiones fixorum astrorum. Hoc autem non videtur fieri, sed semper eadem, apud eadem loca ipsius, & oriuntur, & occidunt.* [In English thus:] Furthermore all that are carried with circular motion, seem to *foreflow; and to move with more than one motion, except the first Sphere; wherefore it is necessary that the Earth move with two motions; whether it be carried about the *middle, or placed in the middle. But if it be so, there would of necessity be alterations and conversions made amongst the fixed Stars. But no such thing is seen to be done, but the same Star doth alwayes rise and set in the same place. In all this I find not any falacy; and my thinks the argument is very forcible.

* Subdeficere.

* Or Centre.

SALV. And this new reading of the place hath confirmed me in the fallacy of the Sillogisme, and moreover, discovered another fallity. Therefore observe. The Positions, or if you will, Conclusions, which *Aristotle* endeavours to oppose, are two; one is that of those, who placing the Earth in the midst of the World, do make it move in it self about its own centre. The other is of those, who constituting it far from the middle, do make it revolve with a circular motion about the middle of the Universe. And both these Positions he conjointly impugneth with one and the same argument. Now I affirm that he is out in both the one and the other impugnation; and that his error against the first Position is an Equivoke or Paralogisme; and his mistake touching the second is a false consequence. Let us begin with the first Assertion, which constituteth the Earth in the midst of the World, and maketh it move in it self about its own centre; and let us confront it with the objection of *Aristotle*; saying, All moveables, that move circularly, seem to *foreflow, and move with more than one Byas, except the first Sphere (that is the pri-

mum

Aristotles argument against the Earths motion, is defective in two things.

* The same word which a little above I tendred stay behind, as a bowle when it meets with

mun mobile) therefore the Earth moving about its own centre, being placed in the middle, must of necessity have two byasses, and foreflow. But if this were so, it would follow, that there should be a variation in the rising and setting of the fixed Stars, which we do not perceive to be done: Therefore the Earth doth not move, &c. Here is the Paralogisme, and to discover it, I will argue with *Aristotle* in this manner. Thou saist, oh *Aristotle*, that the Earth placed in the middle of the World, cannot move in it self (*i.e.* upon its own *axis*) for then it would be requisite to allow it two byasses; so that, if it should not be necessary to allow it more than one Byas onely, thou wouldest not then hold it impossible for it to move onely with that one; for thou wouldst unnecessarily have confined the impossibility to the plurality of byasses; if in case it had no more but one, yet it could not move with that. And because that of all the moveables in the World, thou makest but one alone to move with one sole byas; and all the rest with more than one; and this same moveable thou affirmest to be the first Sphere, namely, that by which all the fixed and erratick Stars seem harmoniously to move from East to West, if in case the Earth may be that first Sphere, that by moving with one byas onely, may make the Stars appear to move from East to West, thou wilt not deny them it: But he that affirmeth, that the Earth being placed in the midst of the World, moveth about its own Axis, ascribes unto it no other motion, save that by which all the Stars appear to move from East to West; and so it cometh to be that first Sphere, which thou thy self acknowledgest to move with but one byas onely. It is therefore necessary, oh *Aristotle*, if thou wilt conclude any thing, that thou demonstrate, that the Earth being placed in the midst of the World, cannot move with so much as one byas onely; or else, that much lesse can the first Sphere have one sole motion; for otherwise thou doest in thy very Sillogisme both commit the fallacy, and detect it, denying, and at that very time proving the same thing. I come now to the second Position, namely, of those who placing the Earth far from the midst of the Universe, make it moveable about the same; that is, make it a Planet and erratick Star; against which the argument is directed, and as to form is concludent, but faileth in matter. For it being granted, that the Earth doth in that manner move, and that with two byasses, yet doth it not necessarily follow that though it were so, it should make alterations in the risings and settings of the fixed Stars, as I shall in its proper place declare. And here I could gladly excuse *Aristotle*; rather I could highly applaud him for having light upon the most subtil argument that could be produced against the *Copernican Hypothesis*; and if the objection be ingenious,

nious, and to outward appearance most powerful, you may see how much more acute and ingenious the solution must be, and not to be found by a wit lesse piercing than that of *Copernicus*; and again from the difficulty in understanding it, you may argue the so much greater difficulty in finding it. But let us for the present suspend our answer, which you shall understand in due time and place, after we have repeated the objection of *Aristotle*, and that in his favour, much strengthened. Now passe we to *Aristotles* third Argument, touching which we need give no farther

The answer to
the third argu-
ment.

reply, it having been sufficiently answered betwixt the discourses of yesterday and to day: In as much as he urgeth, that the motion of grave bodies is naturally by a right line to the centre; and then enquireth, whether to the centre of the Earth, or to that of the Universe, and concludeth that they tend naturally to the centre of the Universe, but accidentally to that of the Earth. Therefore we may proceed to the fourth, upon which its requisite that we stay some time, by reason it is founded upon that experiment, from whence the greater part of the remaining arguments derive all their strength. *Aristotle* saith therefore, that it is a most convincing argument of the Earths immobility, to see that projections thrown or shot upright, return perpendicularly by the same line unto the same place from whence they were shot or thrown. And this holdeth true, although the motion be of a very great height, which could never come to passe, did the Earth move: for in the time that the projected body is moving upwards and downwards in a state of separation from the Earth, the place from whence the motion of the projection began, would be past, by means of the Earths revolution, a great way towards the East, and look how great that space was, so far from that place would the projected body in its descent come to the ground. So that hither may be referred the argument taken from a bullet shot from a Canon directly upwards; as also that other used by *Aristotle* and *Ptolomy*, of the grave bodies that falling from on high, are observed to descend by a direct and perpendicular line to the surface of the Earth. Now that I may begin to untie these knots, I demand of *Simplicius* that in case one should deny to *Ptolomy* and *Aristotle* that weights in falling freely from on high, descend by a right and perpendicular line, that is, directly to the centre, what means he would use to prove it?

SIMPL. The means of the senses; the which assureth us, that that Tower or other altitude, is upright and perpendicular, and sheweth us that that stone, or other grave body, doth slide along the Wall, without inclining a hairs breadth to one side or another; and light at the foot thereof just under the place from whence it was let fall.

SALV.

SALV. But if it should happen that the Terrestrial Globe did move round, and consequently carry the Tower also along with it, and that the stone did then also grate and slide along the side of the Tower, what must its motion be then?

SIMPL. In this case we may rather say its motions: for it would have one wherewith to descend from the top of the Tower to the bottom, and should necessarily have another to follow the course of the said Tower.

SALV. So that its motion should be compounded of two, to wit, of that wherewith it measureth the Tower, and of that other wherewith it followeth the same: From which composition would follow, that the stone would no longer describe that simple right and perpendicular line, but one transverse, and perhaps not streight.

SIMPL. I can say nothing of its non-rectitude, but this I know very well, that it would of necessity be transverse, and different from the other directly perpendicular, which it doth describe, the Earth standing still.

SALV. You see then, that upon the meer observing the falling stone to glide along the Tower, you cannot certainly affirm that it describeth a line which is streight and perpendicular, unless you first suppose that the Earth standeth still.

SIMPL. True; for if the Earth should move, the stones motion would be transverse, and not perpendicular.

SALV. Behold then the Paralogism of Aristotle and Ptolomey to be evident and manifest, and discovered by you your self, wherein that is supposed for known, which is intended to be demonstrated.

SIMPL. How can that be? To me it appeareth that the Syllogism is rightly demonstrated without *petitionem principii*.

SALV. You shall see how it is; answer me a little. Doth he not lay down the conclusion as unknown?

SIMPL. Unknown; why otherwise the demonstrating it would be superfluous.

SALV. But the middle term, ought not that to be known?

SIMPL. Its necessary that it should; for otherwise it would be a proving *ignotum per æquè ignotum*.

SALV. Our conclusion which is to be proved, and which is unknown, is it not the stability of the Earth?

SIMPL. It is the same.

SALV. The middle term, which ought to be known, is it not the streight and perpendicular descent of the stone?

SIMPL. It is so.

SALV. But was it not just now concluded, that we can have no certain knowledg whether that same shall be direct and perpendicular;

This Paralogism of Aristotle and Ptolomey in supposing that for known, which is in question.

Q

dicular, unless we first know that the Earth stands still? Therefore in your Syllogism the certainty of the middle term is assumed from the uncertainty of the conclusion. You may see then, what and how great the Paralogism is.

SAGR. I would, in favour of *Simplicius*, defend *Aristotle* if it were possible, or at least better satisfy my self concerning the strength of your illation. You say, that the seeing the stone rake along the Tower, is not sufficient to assure us, that its motion is perpendicular (which is the middle term of the Syllogism) unless it be presupposed, that the Earth standeth still, which is the conclusion to be proved: For that if the Tower did move together with the Earth, and the stone did slide along the same, the motion of the stone would be transverse, and not perpendicular. But I shall answer, that should the Tower move, it would be impossible that the stone should fall gliding along the side of it; and therefore from its falling in that manner the stability of the Earth is inferred.

SIMPL. It is so; for if you would have the stone in descending to grate upon the Tower, though it were carried round by the Earth, you must allow the stone two natural motions, to wit, the straight motion towards the Centre, and the circular about the Centre, the which is impossible.

SALV. *Aristotle's* defense then consisteth in the impossibility, or at least in his esteeming it an impossibility, that the stone should move with a motion mixt of right and circular: for if he did not hold it impossible that the stone could move to the Centre, and about the Centre at once, he must have understood, that it might come to pass that the cadent stone might in its descent, race the Tower as well when it moved as when it stood still; and consequently he must have perceived, that from this grating nothing could be inferred touching the mobility or immobility of the Earth. But this doth not any way excuse *Aristotle*; as well because he ought to have expressed it, if he had had such a conceit, it being so material a part of his Argument; as also because it can neither be said that such an effect is impossible, nor that *Aristotle* did esteem it so. The first cannot be affirmed, for that by and by I shall shew that it is not onely possible, but necessary: nor much less can the second be averred, for that *Aristotle* himself granteth fire to move naturally upwards in a right line, and to move about with the diurnal motion, imparted by Heaven to the whole Element of Fire, and the greater part of the Air: If therefore he held it not impossible to mix the right motion upwards, with the circular communicated to the Fire and Air from the concave of the Moon, much less ought he to account impossible the mixture of the right motion downwards of the stone, with the circular

Aristotle admitteth that the Fire moveth directly upwards by nature, and round about by participation.

circular which we presuppose natural to the whole Terrestrial Globe, of which the stone is a part.

SIMPL. I see no such thing : for if the element of Fire revolve round together with the Air, it is a very easie, yea a necessary thing, that a spark of fire which from the Earth mounts upwards, in passing thorow the moving air, should receive the same motion, being a body so thin, light, and easie to be moved : but that a very heavy stone, or a Canon bullet, that descendeth from on high, and that is at liberty to move whither it will, should suffer it self to be transported either by the air or any other thing, is altogether incredible. Besides that, we have the Experiment, which is so proper to our purpose, of the stone let fall from the round top of the Mast of a ship; which when the ship lyeth still, falleth at the Partners of the Mast; but when the ship saileth, falls so far distant from that place, by how far the ship in the time of the stones falling had run forward; which will not be a few fathoms, when the ships course is swift.

SALV. There is a great disparity between the case of the Ship and that of the Earth, if the Terrestrial Globe be supposed to have a diurnal motion. For it is a thing very manifest, that the motion of the ship, as it is not natural to it, so the motion of all those things that are in it is accidental; whence it is no wonder that the stone which was retained in the round top, being left at liberty, descendeth downwards without any obligation to follow the motion of the ship. But the diurnal conversion is ascribed to the Terrestrial Globe for its proper and natural motion, and consequently, it is so to all the parts of the said Globe; and, as being impressed by nature, is indelible in them; and therefore that stone that is on the top of the Tower hath an intrinsic inclination of revolving about the Centre of its *Whole* in twenty four hours, and this same natural instinct it exerciseth eternally, be it placed in any state whatsoever. And to be assured of the truth of this, you have no more to do but to alter an antiquated impression made in your mind; and to say, Like as in that I hitherto holding it to be the property of the Terrestrial Globe to rest immoveable about its Centre, did never doubt or question but that all whatsoever parties thereof do also naturally remain in the same state of rest: So it is reason, in case the Terrestrial Globe did move round by natural instinct in twenty four hours, that the intrinsic and natural inclination of all its parts should also be, not to stand still, but to follow the same revolution. And thus without running into any inconvenience, one may conclude, that in regard the motion conferred by the force of * Oars on the Ship, and by it on all the things that are contained within her, is not natural but forreign, it is very reasonable that that stone, it being separated from the ship,

Q 2

The disparity between the fall of a stone from the round top of a ship, and from the top of a tower.

* That you may not suspect my translation, or wonder what Oars have to do with a ship, you are to know that the Author intends the Gallies used in the Mediterranean.

*The part of the
Air inferiour to
the higher moun-
tains doth follow
the motion of the
Earth.*

do reduce its self to its natural disposure, and return to exercise its pure simple instinct given it by nature. To this I add, that it's necessary, that at least that part of the Air which is beneath the greater heights of mountains, should be transported and carried round by the roughness of the Earths surface; or that, as being mixt with many Vapours, and terrene Exhalations, it do naturally follow the diurnal motion, which occurreth not in the Air about the ship rowed by Oars: So that your arguing from the ship to the Tower hath not the force of an illation; because that stone which falls from the round top of the Mast, entereth into a *medium*, which is unconcern'd in the motion of the ship: but that which departeth from the top of the Tower, finds a *medium* that hath a motion in common with the whole Terrestrial Globe; so that without being hindred, rather being assisted by the motion of the air, it may follow the universal course of the Earth.

*The motion of the
Air apt to carry
with it light things,
but not heavy.*

SIMPL. I cannot conceive that the air can imprint in a very great stone, or in a gross Globe of Wood or Ball of Lead, as I suppose of two hundred weight, the motion wherewith its self is moved, and which it doth perhaps communicate to feathers, snow, and other very light things: nay, I see that a weight of that nature, being exposed to any the most impetuous wind, is not thereby removed an inch from its place; now consider with your self whether the air will carry it along therewith.

SALV. There is great difference between your experiment and our case. You introduce the wind blowing against that stone, supposed in a state of rest, and we expose to the air, which already moveth, the stone which doth also move with the same velocity; so that the air is not to conferr a new motion upon it, but onely to maintain, or to speak better, not to hinder the motion already acquired: you would drive the stone with a strange and preternatural motion, and we desire to conserve it in its natural. If you would produce a more pertinent experiment, you should say, that it is observed, if not with the eye of the forehead, yet with that of the mind, what would even, if an eagle that is carried by the course of the wind, should let a stone fall from its talons; which, in regard that at its being let go, it went along with the wind, and after it was let fall it entered into a *medium* that moved with equal velocity, I am very confident that it would not be seen to descend in its fall perpendicularly, but that following the course of the wind, and adding thereto that of its particular gravity, it would move with a transverse motion.

SIMPL. But it would first be known how such an experiment may be made; and then one might judg according to the event. In the mean time the effect of the ship doth hitherto incline to favour our opinion.

SALV.

SALV. Well said you *hitherto*, for perhaps it may anon change countenance. And that I may no longer hold you in suspense, tell me, *Simplicius*, do you really believe, that the Experiment of the ship squares so very well with our purpose, as that it ought to be believed, that that which we see happen in it, ought also to evene in the Terrestrial Globe?

SIMPL. As yet I am of that opinion; and though you have alledged some small disparities, I do not think them of so great moment, as that they should make me change my judgment.

SALV. I rather desire that you would continue therein, and hold for certain, that the effect of the Earth would exactly answer that of the ship: provided, that when it shall appear prejudicial to your cause, you would not be humorous and alter your thoughts. You may haply say, Forasmuch as when the ship stands still, the stone falls at the foot of the Mast; and when she is under sail, it lights far from thence, that therefore by conversion, from the stones falling at the foot is argued the ships standing still, and from its falling far from thence is argued her moving; and because that which occurrerh to the ship, ought likewise to befall the Earth: that therefore from the falling of the stone at the foot of the Tower is necessarily inferred the immobility of the Terrestrial Globe. Is not this your argumentation?

SIMPL. It is; and reduced into that conciseness, as that it is become most easie to be apprehended.

SALV. Now tell me; if the stone let fall from the Round-top; when the ship is in a swift course, should fall exactly in the same place of the ship, in which it falleth when the ship is at anchor, what service would these experiments do you, in order to the ascertaining whether the vessel doth stand still or move?

SIMPL. Just none: Like as, for exemple, from the beating of the pulse one cannot know whether a person be asleep or awake, seeing that the pulse beateth after the same manner in sleeping as in waking.

SALV. Very well. Have you ever tryed the experiment of the Ship?

SIMPL. I have not; but yet I believe that those Authors which alledg the same, have accurately observed it; besides that the cause of the disparity is so manifestly known, that it admits of no question.

SALV. That it is possible that those Authors instance in it, without having made tryal of it, you your self are a good testimony, that without having examined it, alledg it as certain, and in a credulous way remit it to their authority; as it is now not onely possible, but very probable that they likewise did; I mean, did remit the same to their Predecessors, without ever arriving at one that

*The Stone falling
from the Mast of
a Ship lights in the
same place, whe-
ther the Ship doth
move or ly still.*

that had made the experiment : for whoever shall examine the same, shall find the event succeed quite contrary to what hath been written of it : that is, he shall see the stone fall at all times in the same place of the Ship, whether it stand still, or move with any whatsoever velocity. So that the same holding true in the Earth, as in the Ship, one cannot from the stones falling perpendicularly at the foot of the Tower, conclude any thing touching the motion or rest of the Earth.

SIMPL. If you should refer me to any other means than to experience, I verily believe our Disputations would not come to an end in haste ; for this seemeth to me a thing so remote from all humane reason, as that it leaveth not the least place for credulity or probability.

SALV. And yet it hath left place in me for both.

SIMPL. How is this ? You have not made an hundred, no nor one proof thereof ; and do you so confidently affirm it for true ? I for my part will return to my incredulity, and to the confidence I had that the Experiment hath been tried by the principal Authors who made use thereof, and that the event succeeded as they affirm.

SALV. I am assured that the effect will ensue as I tell you ; for so it is necessary that it should : and I farther add, that you know your self that it cannot fall out otherwise, however you feign or seem to feign that you know it not. Yet I am so good at taming of wits, that I will make you confess the same whether you will or no. But *Sagredus* stands very mute, and yet, if I mistake not, I saw him make an offer to speak somewhat.

SAGR. I had an intent to say something, but to tell you true, I know not what it was, for the curiosity that you have moved in me, by promising that you would force *Simplicius* to discover the knowledg which he would conceal from us, hath made me to depose all other thoughts : therefore I pray you to make good your vaunt.

SALV. Provided that *Simplicius* do consent to reply to what I shall ask him, I will not fail to do it.

SIMPL. I will answer what I know, assured that I shall not be much put to it, for that of those things which I hold to be false, I think nothing can be known, in regard that Science respecteth truths and not falsehoods.

SALV. I desire not that you should say or reply, that you know any thing, save that which you most assuredly know. Therefore tell me ; If you had here a flat superficies as polite as a Looking-glass, and of a substance as hard as steel, and that it were not parallel to the Horizon, but somewhat inclining, and that upon it you did put a Ball perfectly spherical, and of a substance grave and hard,

hard, as suppose of brags; what think you it would do being let go? do not you believe (as for my part I do) that it would lie still?

SIMPL. If that superficies were inclining?

SALV. Yes; for so I have already supposed.

SIMPL. I cannot conceive how it should lie still: nay, I am confident that it would move towards the declivity with much propensness.

SALV. Take good heed what you say, *Simplicius*; for I am confident that it would lie still in what ever place you should lay it.

SIMPL. So long as you make use of such suppositions; *Salvatus*, I shall cease to wonder if you infer most absurd conclusions.

SALV. Are you assured, then, that it would freely move towards the declivity?

SIMPL. Who doubts it?

SALV. And this you verily believe, not because I told you so, (for I endeavoured to persuade you to think the contrary) but of your self, and upon your natural judgment.

SIMPL. Now I see what you would be at; you spoke not this as really believing the same; but to try me; and to wrest matter out of my own mouth wherewith to condemn me.

SALV. You are in the right. And how long would that Ball move, and with what velocity? But take notice that I instanced in a Ball exactly round, and a plain exquisitely polished, that all external and accidental impediments might be taken away. And so would I have you remove all obstructions caused by the Airs resistance to division, and all other casual obstacles, if any other there can be.

SIMPL. I very well understand your meaning; and as to your demand, I answer, that the Ball would continue to move *in infinitum*, if the inclination of the plain should so long last, and continually with an accelerating motion; for such is the nature of ponderous moveables, that *vires acquirant eundo*: and the greater the declivity was, the greater the velocity would be.

SALV. But if one should require that that Ball should move upwards on that same superficies, do you believe that it would so do?

SIMPL. Not spontaneously; but being drawn, or violently thrown, it may.

SALV. And in case it were thrust forward by the impression of some violent *impetus* from without, what and how great would its motion be?

SIMPL. The motion would go continually decreasing and retarding,

tarding, as being contrary to nature; and would be longer or shorter, according to the greater or less impulse, and according to the greater or less acclivity.

SALV. It seems, then, that hitherto you have explained to me the accidents of a moveable upon two different Planes; and that in the inclining plane, the grave moveable doth spontaneously descend, and goeth continually accelerating, and that to retain it in rest, force must be used therein: but that on the ascending plane, there is required a force to thrust it forward, and also to stay it in rest, and that the motion impressed goeth continually diminishing, till that in the end it cometh to nothing. You say yet farther, that in both the one and the other case, there do arise differences from the planes having a greater or less declivity or acclivity; so that the greater inclination is attended with the greater velocity; and contrariwise, upon the ascending plane, the same moveable thrown with the same force, moveth a greater distance, by how much the elevation is less. Now tell me, what would befall the same moveable upon a superficies that had neither acclivity nor declivity?

SIMPL. Here you must give me a little time to consider of an answer. There being no declivity, there can be no natural inclination to motion: and there being no acclivity, there can be no resistance to being moved; so that there would arise an indifference between propension and resistance of motion; therefore, methinks it ought naturally to stand still. But I had forgot my self: it was but even now that *Sagredus* gave me to understand that it would so do.

SALV. So I think, provided one did lay it down gently: but if it had an *impetus* given it towards any part, what would follow?

SIMPL. There would follow, that it should move towards that part.

SALV. But with what kind of motion? with the continually accelerated, as in declining planes; or with the successively retarded, as in those ascending.

SIMPL. I cannot tell how to discover any cause of acceleration, or retardation, there being no declivity or acclivity.

SALV. Well: but if there be no cause of retardation, much less ought there to be any cause of rest. How long therefore would you have the moveable to move?

SIMPL. As long as that superficies, neither inclined nor declined shall last.

SALV. Therefore if such a space were interminate, the motion upon the same would likewise have no termination, that is, would be perpetual.

SIMPL.

SIMP. I think so ; if so be the moveable be of a matter durable.

SALV. That hath been already supposed ; when it was said, that all external and accidental impediments were removed , and the brittlenesse of the moveable in this our case , is one of those impediments accidental. Tell me now , what do you think is the cause that that same Ball moveth spontaneously upon the inclining plane, and not without violence upon the erected ?

SIMP. Because the inclination of grave bodies is to move towards the centre of the Earth , and onely by violence upwards towards the circumference ; and the inclining superficies is that which acquireth vicinity to the centre , and the ascending one, remoteness.

SALV. Therefore a superficies , which should be neither declining nor ascending , ought in all its parts to be equally distant from the centre. But is there any such superficies in the World ?

SIMP. There is no want thereof : Such is our Terrestrial Globe , if it were more even , and not as it is rough and mountainous ; but you have that of the Water , at such time as it is calm and still.

SALV. Then a ship which moveth in a calm at Sea , is one of those moveables , which run along one of those superficies that are neither declining nor ascending , and therefore disposed , in case all obstacles external and accidental were removed , to move with the impulse once imparted incessantly and uniformly.

SIMP. It should seem to be so.

SALV. And that stone which is on the round top , doth not it move , as being together with the ship carried about by the circumference of a Circle about the Centre ; and therefore consequently by a motion in it indelible ; if all extern obstacles be removed ? And is not this motion as swift as that of the ship.

SIMP. Hitherto all is well. But what followeth ?

SALV. Then in good time recant , I pray you , that your last conclusion ; if you are satisfied with the truth of all the premises.

SIMP. By my last conclusion , you mean , That that same stone moving with a motion indelibly impressed upon it , is not to leave , nay rather is to follow the ship , and in the end to light in the self same place , where it falleth when the ship lyeth still ; and so I also grant it would do , in case there were no outward impediments that might disturb the stones motion ; after its being let go , the which impediments are two , the one is the moveables inability to break through the air with its meer *impetus* onely , it being deprived of that of the strength of Oars , of which it had

R

been

been partaker; as part of the ship, at the time that it was upon the Mast; the other is the new motion of descent, which also must needs be an hinderance of that other progressive motion.

SALV. As to the impediment of the Air, I do not deny it you; and if the thing falling were a light matter, as a feather, or a lock of wool, the retardation would be very great, but in an heavy stone is very exceeding small. And you your self but even now did say, that the force of the most impetuous wind sufficeth not to stir a great stone from its place; now do but consider what the calmer air is able to do, being encountered by a stone no more swift than the whole ship. Nevertheless, as I said before, I do allow you this small effect, that may depend upon such an impediment; like as I know, that you will grant to me, that if the air should move with the same velocity that the ship and stone hath, then the impediment would be nothing at all. As to the other of the additional motion downwards; in the first place it is manifest, that these two, I mean the circular, about the centre, and the streight, towards the centre, are not contraries, or destructive to one another, or incompatible. Because that as to the moveable, it hath no repugnance at all to such motions; for you your self have already confest the repugnance to be against the motion which removeth from the centre, and the inclination to be towards the motion which approacheth to the centre. Whence it doth of necessity follow, that the moveable hath neither repugnance, nor propension to the motion which neither approacheth, nor goeth from the centre, nor consequently is there any cause for the diminishing in it the faculty impressed. And forasmuch as the moving cause is not one alone, which it hath attained by the new operation of retardation; but that they are two, distinct from each other, of which, the gravity attends only to the drawing of the moveable towards the centre, and the vertue impress'd to the conducting it about the centre, there remaineth no occasion of impediment.

The project according to Aristotle, is not moved by vertue impressed, but by the medium.

SIMPL. Your argumentation, to give you your due, is very probable; but in reality it is invelliped with certain intricacies, that are not easie to be extricated. You have all along built upon a supposition, which the *Peripatetick* Schools will not easily grant you, as being directly contrary to *Aristotle*, and it is to take for known and manifest, That the project separated from the projicient, continueth the motion by *vertue impressed* on it by the said projicient, which *vertue impressed* is a thing as much detested in *Peripatetick* Philosophy, as the passage of any accident from one subject into another. Which doctrine doth hold, as I believe it is well known unto you, that the project is carried by the medium, which in our case happeneth to be the Air. And there-

therefore if that stone let fall from the round top, ought to follow the motion of the ship, that effect should be ascribed to the Air, and not to the vertue impressed. But you presuppose that the Air doth not follow the motion of the ship, but is tranquil. Moreover, he that letteth it fall, is not to throw it, or to give it *impetus* with his arm, but ought barely to open his hand and let it go; and by this means, the stone, neither through the vertue impressed by the projicient, nor through the help of the Air, shall be able to follow the ships motion, and therefore shall be left behind.

SALV. I think then that you would say, that if the stone be not thrown by the arm of that person, it is no longer a projection.

SIMP. It cannot be properly called a motion of projection.

SALV. So then that which *Aristotle* speaks of the motion, the moveable, and the mover of the projects, hath nothing to do with the business in hand; and if it concern not our purpose, why do you alledg the same?

SIMP. I produce it on the occasion of that impressed vertue, named and introduced by you, which having no being in the World, can be of no force; for *non-entium nulla sunt operationes*; and therefore not onely of projected, but of all other preternatural motions, the moving cause ought to be ascribed to the *medium*, of which there hath been no due consideration had; and therefore all that hath been said hitherto is to no purpose.

SALV. Go to now, in good time. But tell me, seeing that your instance is wholly grounded upon the nullity of the vertue impressed, if I shall demonstrate to you, that the *medium* hath nothing to do in the continuation of projects, after they are separated from the projicient, will you admit of the impressed vertue, or will you make another attempt to overthrow it?

SIMP. The operation of the *medium* being removed, I see not how one can have recourse to any thing else save the faculty impressed by the mover.

SALV. It would be well, for the removing, as much as is possible, the occasions of multiplying contentions, that you would explain with as much distinctness as may be, what is that operation of the *medium* in continuing the motion of the project.

SIMP. The projicient hath the stone in his hand, and with force and violence throws his arm, with which jactation the stone doth not move so much as the circumambient Air; so that when the stone at its being forsaken by the hand, findeth it self in the Air, which at the same time moveth with impetuosity, it is thereby born away; for, if the air did not operate, the stone would fall at the foot of the projicient or thrower.

R 2

SALV.

Operation of the medium in continuing the motion of the project.

Many experiments, and reasons against the cause of the motion of projects, assigned by Aristotle.

SALV. And was you so credulous, as to suffer your self to be perswaded to believe these fopperies, so long as you had your senses about you to confute them, and to understand the truth thereof? Therefore tell me, that great stone, and that Canon bullet, which but onely laid upon a table, did continue immoveable against the most impetuous winds, according as you a little before did affirm, if it had been a ball of cork or other light stuffe, think you that the wind would have removed it from its place?

SIMP. Yes, and I am assured that it would have blown it quite away, and with so much more velocity, by how much the matter was lighter, for upon this reason we see the clouds to be transported with a velocity equal to that of the wind that drives them.

SALV. And what is the Wind?

SIMP. The Wind is defined to be nothing else but air moved.

SALV. Then the moved air doth carry light things more swiftly, and to a greater distance, then it doth heavy.

SIMP. Yes certainly.

SALV. But if you were to throw with your arm a stone, and a lock of cotton wool, which would move swiftest and farthest?

SIMP. The stone by much; nay the wool would fall at my feet.

SALV. But, if that which moveth the projected substance, after it is delivered from the hand, be no other than the air moved by the arm, and the moved air do more easily bear away light than grave matters, how cometh it that the project of wool flieth not farther, and swifter than that of stone? Certainly it argueth that the stone hath some other impulse besides the motion of the air. Furthermore, if two strings of equal length did hang at yonder beam, and at the end of one there was fastened a bullet of lead, and a ball of cotton wool at the other, and both were carried to an equal distance from the perpendicular, and then let go; it is not to be doubted, but that both the one and the other would move towards the perpendicular, and that being carried by their own *impetus*; they would go a certain space beyond it, and afterwards return thither again. But which of these two pendent Globes do you think, would continue longest in motion, before that it would come to rest in its perpendicularity?

SIMP. The ball of lead would swing to and again many times, and that of wool but two or three at the most.

SALV. So that that *impetus* and that *mobility* whatsoever is the cause thereof, would conserve its self longer in grave substances, than light; I proceed now to another particular, and demand of you, why the air doth not carry away that Lemon which is upon that same Table?

SIMP.

DIALOGUE II.

133

SIMP. Because that the air it self is not moved

SALV. It is requisite then, that the projicient do confer motion on the Air, with which it afterward moveth the project. But if such a motion cannot be impressed [*i. e. imparted*] it being impossible to make an accident passe out of one subject into another, how can it passe from the arm into the Air? Will you say that the Air is not a subject different from the arm?

SIMP. To this it is answered that the Air, in regard it is neither heavy nor light in its own Region, is disposed with facility to receive every impulse, and also to retain the same.

SALV. But if those *penduli* even now named, did prove unto us, that the moveable, the lesse it had of gravity, the lesse apt it was to conserve its motion, how can it be that the Air which in the Air hath no gravity at all, doth of it self alone retain the motion acquired? I believe, and know that you by this time are of the same opinion, that the arm doth not sooner return to rest, than doth the circumambient Air. Let's go into the Chamber, and with a towel let us agitate the Air as much as we can, and then holding the cloth still, let a little candle be brought, that was lighted in the next room, or in the same place let a leaf of beaten Gold be left at liberty to flie any way, and you shall by the calm vagation of them be assured that the Air is immediately reduced to tranquility. I could alledg many other experiments to the same purpose, but if one of these should not suffice, I should think your folly altogether incurable.

SAGR. When an arrow is shot against the Wind, how incredible a thing is it, that that same small filament of air, impelled by the bow-string, should in despite of fate go along with the arrow? But I would willingly know another particular of *Aristotle*, to which I intreat *Simplicius* would vouchsafe me an answer. Supposing that with the same Bow there were shot two arrows, one just after the usual manner, and the other side-ways, placing it long-ways upon the Bow-string, and then letting it flie, I would know which of them would go farthest. Favour me, I pray you with an answer, though the question may seem to you rather ridiculous than otherwise; and excuse me, for that I, who am, as you see, rather blockish, than not, can reach no higher with my speculative faculty.

SIMP. I have never seen an arrow shot in that manner, yet nevertheless I believe, that it would not flie side-long, the twentieth part of the space that it goeth end-ways.

SAGR. And for that I am of the same opinion, hence it is, that I have a doubt risen in me, whether *Aristotle* doth not contradict experience. For as to experience, if I lay two arrows upon this Table, in a time vvhhen a strong Wind bloweth, one towards the

the course of the wind, and the other sidelong, the wind will quickly carry away this later, and leave the other where it was; and the same to my seeming, ought to happen, if the Doctrine of *Aristotle* were true, of those two shot out of a Bow: forasmuch as the arrow shot sideways is driven by a great quantity of Air, moved by the bowstring, to wit by as much as the said string is long, whereas the other arrow receiveth no greater a quantity of air, than the small circle of the strings thickness. And I cannot imagine what may be the reason of such a difference, but would fain know the same.

SIMP. The cause seemeth to me sufficiently manifest; and it is, because the arrow shot endways, hath but a little quantity of air to penetrate, and the other is to make its way through a quantity as great as its whole length.

SALV. Then it seems the arrows shot, are to penetrate the air? but if the air goeth along with them, yea, is that which carrieth them, what penetration can they make therein? Do you not see that, in this case, the arrow would of necessity move with greater velocity than the air? and this greater velocity, what doth confer it on the arrow? Will you say the air giveth them a velocity greater than its own? Know then, *Simplicius*, that the business proceeds quite contrary to that which *Aristotle* saith, and that the *medium* conferreth the motion on the project, is as false, as it is true, that it is the only thing which procureth its obstruction; and having known this, you shall understand without finding any thing whereof to make question, that if the air be really moved, it doth much better carry the dart along with it longways, than endways, for that the air which impelleth it in that posture, is much, and in this very little. But shooting with the Bow, forasmuch as the air stands still, the transverse arrow, being to force its passage through much air, comes to be much impeded, and the other that was nock't easily overcometh the obstruction of the small quantity of air, which opposeth it self thereto.

*The medium doth
impede and not con-
fer the motion of
project.*

SALV. How many Propositions have I observed in *Aristotle*, (meaning still in Natural Philosophy) that are not onely false, but false in such sort, that its diametrical contrary is true, as it happens in this case. But pursuing the point in hand, I think that *Simplicius* is perswaded, that, from seeing the stone always to fall in the same place, he cannot conjecture either the motion or stability of the Ship: and if what hath been hitherto spoken, should not suffice, there is the Experiment of the *medium* which may thorowly assure us thereof; in which experiment, the most that could be seen would be, that the cadent moveable might be left behind, if it were light, and that the air did not follow the motion of the ship: but in case the air should move with equal velocity,

velocity, no imaginable diversity could be found either in this, or any other experiment whatsoever, as I am anon to tell you. Now if in this case there appeareth no difference at all, what can be pretended to be seen in the stone falling from the top of the Tower, where the motion in gyration is not adventitious, and accidental, but natural and eternal; and where the air exactly followeth the motion of the Tower, and the Tower that of the Terrestrial Globe? have you any thing else to say, *Simplicius*, upon this particular?

SIMP. No more but this, that I see not the mobility of the Earth as yet proved.

SALV. Nor have I any intention at this time, but only to shew, that nothing can be concluded from the experiments alledged by our adversaries for convincing Arguments: as I think I shall prove, the others to be.

SAGR. I beseech you, *Salviatus*, before you proceed any farther, to permit me to start certain questions, which have been rousing in my fancy all the while that you with so much patience and equanimity, was minutely explaining to *Simplicius* the experiment of the Ship.

SALV. We are here met with a purpose to dispute, and it's fit that every one should move the difficulties that he meets withall; for this is the way to come to the knowledg of the truth. Therefore speak freely.

SAGR. If it be true, that the *impetus* wherewith the ship moves, doth remain indelibly impress'd in the stone, after it is let fall from the Mast; and if it be farther true, that this motion brings no impediment or retardment to the motion directly downwards, natural to the stone: it's necessary, that there do an effect ensue of a very wonderful nature. Let a Ship be supposed to stand still, and let the time of the falling of a stone from the Masts Round-top to the ground, be two beats of the pulse; let the Ship afterwards be under sail, and let the same stone depart from the same place, and it, according to what hath been premised, shall still take up the time of two pulses in its fall, in which time the ship will have run, suppose, twenty yards; so that the true motion of the stone will be a transverse line, considerably longer than the first straight and perpendicular line, which is the length of the *Mast, and yet nevertheless the *stone will have past it in the same time. Let it be farther supposed, that the Ships motion is much more accelerated, so that the stone in falling shall be to pass a transverse line much longer than the other; and in sum, increasing the Ships velocity as much as you will, the falling stone shall describe its transverse lines still longer and longer, and yet shall pass them all in those self same two pulses. And in this fashion, if a Canon were level'd

An admirable accident in the motion of projects.

*By the length of the mast he means the distance between the upper-deck and Round-top.

*La palla.

level'd on the top of a Tower, and shots were made therewith point blank, that is, paralel to the Horizon, let the Piece have a greater or less charge, so as that the ball may fall sometimes a thousand yards distant, sometimes four thousand, sometimes six, sometimes ten, &c. and all these shots shall curry or finish their ranges in times equal to each other, and every one equal to the time which the ball would take to pass from the mouth of the Piece to the ground, being left, without other impulse, to fall simply downwards in a perpendicular line. Now it seems a very admirable thing, that in the same short time of its falling perpendicularly down to the ground, from the height of, suppose, an hundred yards, the same ball, being thrust violently out of the Piece by the Fire, should be able to pass one while four hundred, another while a thousand, another while four, another while ten thousand yards, so as that the said ball in all shots made point blank, always continueth an equal time in the air.

SALV. The consideration for its novelty is very pretty, and if the effect be true, very admirable: and of the truth thereof, I make no question: and were it not for the accidental impediment of the air, I verily believe, that, if at the time of the balls going out of the Piece, another were let fall from the same height directly downwards, they would both come to the ground at the same instant, though that should have curried ten thousand miles in its range, and this but an hundred onely: presupposing the surface of the Earth to be equal, which to be assured of, the experiment may be made upon some lake. As for the impediment which might come from the air, it would consist in retarding the extreme swift motion of the shot. Now, if you think fit, we will proceed to the solution of the other Objections, seeing that *Simplicius* (as far as I can see) is convinc'd of the nullity of this first, taken from things falling from on high downwards.

SIMP. I find not all my scruples removed, but it may be the fault is my own, as not being of so easie and quick an apprehension as *Sagredus*. And it seems to me, that if this motion, of which the stone did partake whilst it was on the Round-top of the Ships Mast, be, as you say, to conserve it self indelibly in the said stone, even after it is separated from the Ship, it would follow, that likewise in case any one, riding a horse that was upon his speed, should let a bowl drop out of his hand, that bowl being fallen to the ground would continue its motion and follow the horses steps, without tarrying behind him: the which effect, I believe, is not to be seen, unless when he that is upon the horse should throw it with violence that way towards which he runneth; but otherwise, I believe it will stay on the ground in the same place where it fell.

SALV.

SALV. I believe that you very much deceive your self, and am certain, that experience will shew you the contrary, and that the ball being once arrived at the ground, will run together with the horse, not staying behind him, unless so far as the asperity and unevenness of the Earth shall hinder it. And the reason seems to me very manifest: for if you, standing still, throw the said ball along the ground, do you think it would not continue its motion even after you had delivered it out of your hand? and that for so much a greater space, by how much the superficies were more smooth, so that *v. g.* upon ice it would run a great way?

SIMP. There is no doubt of it, if I give it *impetus* with my arm; but in the other case it is supposed, that he who is upon the horse, onely drops it out of his hand.

SALV. So I desire that it should be: but when you throw it with your arm, what other remaineth to the ball being once gone out of your hand, than the motion received from your arm, which motion being conserved in the ball, it doth continue to carry it forward? Now, what doth it import, that that *impetus* be conferred on the ball rather from the arm than from the horse? Whilst you were on horseback, did not your hand, and consequently the ball run as fast as the horse it self? Doubtless it did: therefore in onely opening of the hand, the ball departs with the motion already conceived, not from your arm, by your particular motion, but from the motion dependant on the said horse, which cometh to be communicated to you, to your arm, to your hand, and lastly to the ball. Nay, I will tell you farther, that if the rider upon his speed fling the ball with his arm to the part contrary to the course, it shall, after it is fallen to the ground, sometimes (albeit thrown to the contrary part) follow the course of the horse, and sometimes lie still on the ground; and shall onely move contrary to the said course, when the motion received from the arm, shall exceed that of the carrier in velocity. And it is a vanity, that of some, who say that a horseman is able to cast a javelin thorow the air, that way which the horse runs, and with the horse to follow and overtake the same; and lastly, to catch it again. It is, I say, a vanity, for that to make the project return into the hand, it is requisite to cast it upwards, in the same manner as if you stood still. For, let the carrier be never so swift, provided it be uniform, and the project not over-light, it shall always fall back again into the hand of the projectant, though never so high thrown.

SAGR. By this Doctrine I come to know some Problems very curious upon this subject of projections; the first of which must seem very strange to *Simplicius*. And the Problem is this; I affirm it to be possible, that the ball being barely dropt or let fall, by one that any way runneth very swiftly, being arrived at the

Sundry curious Problems, touching the motions of projects.

S

Earth,

Earth, doth not onely follow the course of that person, but doth much out go him. Which Problem is connexed with this, that the moveable being thrown by the projicient above the plane of the Horizon, may acquire new velocity, greater by far than that confer'd upon it by the projicient. The which effect I have with admiration observed, in looking upon those who use the sport of tops, which, so loon as they are let out of the hand, are seen to move in the air with a certain velocity, the which they afterwards much encrease at their coming to the ground; and if whipping them, they rub at any uneven place that makes them skip on high, they are seen to move very slowly through the air, and falling again to the Earth, they still come to move with a greater velocity: But that which is yet more strange, I have farther observed, that they not onely turn always more swiftly on the ground, than in the air, but of two spaces both upon the Earth, sometimes a motion in the second space is more swift than in the first. Now what would *Simplicius* say to this?

SIMP. He would say in the first place, that he had never made such an observation. Secondly, he would say, that he did not believe the same. He would say again, in the third place, that if you could assure him thereof, and demonstratively convince him of the same, he would account you a great Dæmon.

SAGR. I hope then that it is one of the Socratick, not infernal ones. But that I may make you understand this particular, you must know, that if a person apprehend not a truth of himself, it is impossible that others should make him understand it: I may indeed instruct you in those things which are neither true nor false; but the true, that is, the necessary, namely, such as it is impossible should be otherwise, every common capacity either comprehendeth them of himself, or else it is impossible he should ever know them. And of this opinion I am confident is *Salvatus* also: and therefore I tell you, that the reasons of the present Problems are known by you, but it may be, not apprehended.

SIMP. Let us, for the present, pass by that controversie, and permit me to plead ignorance of these things you speak of, and try whether you can make me capable of understanding these Problems.

SAGR. This first dependeth upon another, which is, Whence cometh it, that setting a top with the lash, it runneth farther, and consequently with greater force, than when its set with the fingers?

SIMP. *Aristotle* also makes certain Problems about these kinds of projects.

SALV. He doth so; and very ingenious they are: particularly, That, Whence it cometh to pass that round tops run better than the square?

SAGR.

DIALOGUE II.

139

SAGR. And cannot you, *Simplicius*, give a reason for this, without others prompting you?

SIMP. Very good, I can so; but leave your jeering.

SAGR. In like manner you do know the reason of this other also. Tell me therefore; know you that a thing which moveth, being impeded stands still?

SIMP. I know it doth, if the impediment be so great as to suffice.

SAGR. Do you know, that moving upon the Earth is a greater impediment to the moveable, than moving in the air, the Earth being rough and hard, and the air soft and yielding?

SIMP. And knowing this, I know that the top will turn faster in the air, than on the ground, so that my knowledg is quite contrary to what you think it.

SAGR. Fair and softly, *Simplicius*. You know that in the parts of a moveable, that turneth about its centre, there are found motions towards all sides; so that some ascend, others descend; some go forwards, others backwards?

SIMP. I know it, and *Aristotle* taught me the same.

SAGR. And with what demonstration, I pray you?

SIMP. With that of sense.

SAGR. *Aristotle*, then, hath made you see that which without him you would not have seen? Did he ever lend you his eyes? You would say, that *Aristotle* hath told, advertised, remembered you of the same; and not taught you it. When then a top, without changing place, turns round, (or in the childrens phrase, sleepeth) not paralel, but erect to the Horizon, some of its parts ascend, and the opposite descend; the superiour go one way, the inferiour another. Fancie now to your self, a top, that without changing place, swiftly turns round in that manner, and stands suspended in the air, and that in that manner turning, it be let fall to the Earth perpendicularly, do you believe, that when it is arrived at the ground, it will continue to turn round in the same manner, without changing place, as before?

SIMP. No, Sir.

SAGR. What will it do then?

SIMP. It will run along the ground very fast.

SAGR. And towards what part?

SIMP. Towards that, whither its *reeling carrieth it.

SAGR. In its reeling there are parts, that is the uppermost, which do move contrary to the inferiour; therefore you must instance which it shall obey: for as to the parts ascending and descending, the one kind will not yield to the other; nor will they all go downwards, being hindered by the Earth, nor upwards as being heavy.

* Vertigine.

SIMP. The top will run reeling along the floor towards that part whither its upper parts encline it.

SAGR. And why not whither the contrary parts tend, namely, those which touch the ground?

SIMP. Because those upon the ground happen to be impeded by the roughness of the touch; that is, by the floors unevenness; but the superiour, which are in the tenuous and flexible air, are hindred very little, if at all; and therefore the top will obey their inclination.

SAGR. So that that tactiō, if I may so say, of the neither parts on the floor, is the cause that they stay, and onely the upper parts spring the top forward.

SALV. And therefore, if the top should fall upon the ice, or other very smooth superficies, it would not so well run forward, but might peradventure continue to revolve in it self, (or sleep) without acquiring any progressive motion.

SAGR. It is an easie thing for it so to do; but yet nevertheless, it would not so speedily come to sleep, as when it falleth on a superficies somewhat rugged. But tell me, *Simplicius*, when the top turning round about it self, in that manner, is let fall, why doth it not move forwards in the air, as it doth afterwards when it is upon the ground?

SIMP. Because having air above it, and beneath, neither those parts, nor these have any where to touch, and not having more occasion to go forward than backward, it falls perpendicularly.

SAGR. So then the onely reeling about its self, without other *impetus*, can drive the top forward, being arrived at the ground, very nimbly. Now proceed we to what remains. That lath, which the driver tyeth to his Top-stick, and with which, winding it about the top, he sets it (*i. e.* makes it go) what effect hath it on the said top?

SIMP. It constrains it to turn round upon its toe, that so it may free it self from the Top-lath.

SAGR. So then, when the top arriveth at the ground, it cometh all the way turning about its self, by means of the lath. Hath it not reason then to move in it self more swiftly upon the ground, than it did whilst it was in the air?

SIMP. Yes doubtless; for in the air it had no other impulse than that of the arm of the projicient; and if it had also the reeling, this (as hath been said) in the air drives it not forward at all: but arriving at the floor, to the motion of the arm is added the progression of the reeling, whereby the velocity is redoubled. And I know already very well, that the top skipping from the ground, its velocity will deminish, because the help of its circulation is wanting; and returning to the Earth will get it again, and by that means

means move again faster, than in the air. It onely rests for me to understand; whether in this second motion on the Earth it move more swiftly, than in the first; for then it would move *in infinitum*, alwayes accelerating.

SAGR. I did not absolutely affirm, that this second motion is more swift than the first; but that it may happen so to be sometimes.

SIMP. This is that, which I apprehend not, and which I desire to know.

SAGR. And this also you know of your self. Therefore tell me: When you let the top fall out of your hand, without making it turn round (*i. e.* setting it) what will it do at its coming to the ground?

SIMP. Nothing, but there lie still.

SAGR. May it not chance, that in its fall to the ground it may acquire a motion? Think better on it.

SIMP. Unless we let it fall upon some inclining stone, as children do playing at ** Chiosa*, and that falling side-ways upon the same, it do acquire the motion of turning round upon its toe, wherewith it afterwards continueth to move progressively on the floor, I know not in what other manner it can do any thing but lie still where it falleth.

**A Game in Italy, which is, to glide balls down an inclining stone, &c.*

SAGR. You see then that in some case it may acquire a new revolution. When then the top jerked up from the ground, falleth down again, why may it not casually hit upon the declivity of some stone fixed in the floor, and that hath an inclination that way towards which it moveth, and acquiring by that slip a new whirl over and above that conferred by the last, why may it not redouble its motion, and make it swifter than it was at its first lighting upon the ground?

SIMP. Now I see that the same may easily happen. And I am thinking that if the top should turn the contrary way, in arriving at the ground, it would work a contrary effect, that is, the motion of the accidental whirl would retard that of the proficient.

SAGR. And it would sometimes wholly retard and stop it, in case the revolution of the top were very swift. And from hence ariseth the resolution of that slight, which the more skilful Tennis Players use to their advantage; that is, to gull their adversary by cutting (for so is their Phrase) the Ball; which is, to return it with a side Racket, in such a manner, that it doth thereby acquire a motion by it self contrary to the projected motion, and so by that means, at its coming to the ground, the rebound, which if the ball did not turn in that manner, would be towards the adversary, giving him the usual time to tesse it back again, doth fail,

*A Game in *Italy*,
wherein they strive
who shall trundle
or throw a wooden
bowle neereft to an
assigned mark.

fail, and the ball runs tripping along the ground, or rebounds lesse than usual, and breaketh the time of the return. Hence it is that you see, those who play at *Stool-ball, when they play in a stony way, or a place full of holes and rubs that make the ball trip an hundred several wayes, never suffering it to come neer the mark, to avoid them all, they do not trundle the ball upon the ground, but throw it, as if they were to pitch a quait. But because in throwing the ball, it issueth out of the hand with some roling conferred by the fingers, when ever the hand is under the ball, as it is most commonly held; whereupon the ball in its lighting on the ground neer to the mark, between the motion of the projectile and that of the roling, would run a great way from the same: To make the ball stay, they hold it artificially, with their hand uppermost, and it undermost, which in its delivery hath a contrary twirl or roling conferred upon it by the fingers, by means whereof in its coming to the ground neer the mark it stays there, or runs very very little forwards. But to return to our principal problem which gave occasion for starting these others; I say it is possible that a person carried very swiftly, may let a ball drop out of his hand, that being come to the Earth, shall not onely follow his motion, but also out-go it, moving with a greater velocity. And to see such an effect, I desire that the course may be that of a Chariot, to which on the out-side let a declining board be fastened; so as that the neither part may be towards the horses, and the upper towards the hind Wheel. Now, if in the Chariots full career, a man within it, let a ball fall gliding along the declivity of that board, it shall in roling downward acquire a particular *vertigo* or turning, the which added to the motion impressed by the Chariot, will carrie the ball along the ground much faster than the Chariot. And if one accommodate another declining board over against it, the motion of the Chariot may be qualified so, that the ball, gliding downwards along the board, in its coming to the ground shall rest immoveable, and also shall sometimes run the contrary way to the Chariot. But we are strayed too far from the purpose, therefore if *Simplicius* be satisfied with the resolution of the first argnment against the Earths mobility, taken from things falling perpendicularly, we may passe to the rest.

SALV. The digressions made hitherto, are not so alienated from the matter in hand, as that one can say they are wholly strangers to it. Besides these argumentations depend on those things that start up in the fancy not of one person, but of three, that we are: And moreover we discourse for our pleasure, nor are we obliged to that strictnesse of one who *ex professo* treateth methodically of an argument, with an intent to publish the same.

I

I will not consent that our Poem should be so confined to that unity, as not to leave us fields open for Epsody's, which every small connection should suffice to introduce; but with almost as much liberty as if we were met to tell stories, it shall be lawful for me to speak, what ever your discourse brings into my mind.

SAGR. I like this motion very well; and since we are at this liberty, let me take leave, before we passe any farther to ask of you *Salviatus*, whether you did ever consider what that line may be that is described by the grave moveable naturally falling down from the top of a Tower; and if you have reflected on it, be pleased to tell me what you think thereof.

SALV. I have sometimes considered of it, and make no question, that if one could be certain of the nature of that motion wherewith the grave body descendeth to approach the centre of the Terrestrial Globe, mixing it self afterwards with the common circular motion of the diurnal conversion; it might be exactly found what kind of line that is, that the centre of gravity of the moveable describeth in those two motions.

SAGR. Touching the simple motion towards the centre dependent on the gravity, I think that one may confidently, without error, believe that it is by a right line, as it would be, were the Earth immoveable.

SALV. As to this particular, we may not onely believe it, but experience rendereth us certain of the same.

SAGR. But how doth experience assure us thereof, if we never see any motions but such as are composed of the two, circular and descending.

SALV. Nay rather *Sagredus* we onely see the simple motion of descent; since that other circular one common to the Earth, the Tower and our selves remains imperceptible, and as if it never were, and there remaineth perceptible to us that of the stone, onely not participated by us, and for this, sense demonstrateth that it is by a right line, ever parallel to the said Tower, which is built upright and perpendicular upon the Terrestrial surface.

SAGR. You are in the right; and this was but too plainly demonstrated to me even now, seeing that I could not remember so easie a thing; but this being so manifest, what more is it that you say you desire, for understanding the nature of this motion downwards?

SALV. It sufficeth not to know that it is streight, but its requisite to know whether it be uniform, or irregular; that is, whether it maintain alwayes one and the same velocity, or else goeth retarding or accelerating.

SAGR. It is already clear, that it goeth continually accelerating.

SALV.

SALV. Neither doth this suffice, but its requisite to know according to what proportion such acceleration is made; a Problem, that I believe was never hitherto understood by any Philosopher or Mathematician; although Philosophers, and particularly the *Peripateticks*, have writ great and entire Volumes, touching motion.

SIMP. Philosophers principally busie themselves about universals; they find the definitions and more common symptomes, omitting certain subtilties and niceties, which are rather curiosities to the Mathematicians. And *Aristotle* did content himself to define excellently what motion was in general; and of the local, to shew the principal qualities, to wit, that one is natural, another violent; one is simple, another compound; one is equal, another accelerate; and concerning the accelerate, contents himself to give the reason of acceleration, remitting the finding out of the proportion of such acceleration, and other particular accidents to the Mechanician, or other inferiour Artist.

SAGR. Very well *Simplicius*. But you *Salviatus*, when you descend sometimes from the Throne of *Peripatetick* Majesty, have you ever thrown away any of your hours in studying to find this proportion of the acceleration of the motion of descending grave bodies?

SALV. There was no need that I should study for it, in regard that the *Academick* our common friend, heretofore shewed me a Treatise of his * *De Motu*, where this, and many other accidents were demonstrated. But it would be too great a digression, if for this particular, we should interrupt our present discourse, (which yet it self is also no better than a digression) and make as the Saying is, a Comedy within a Comedy.

SAGR. I am content to excuse you from this narration for the present, provided that this may be one of the Propositions reserved to be examined amongst the rest in another particular meeting, for that the knowledg thereof is by me very much desired; and in the mean time let us return to the line described by the grave body in its fall from the top of the Tower to its base.

SALV. If the right motion towards the centre of the Earth was uniforme; the circular towards the East being also uniforme, you would see composed of them both a motion by a spiral line, of that kind with those defined by *Archimedes* in his Book *De Spirilibus*, which are, when a point moveth uniformly upon a right line; whilst that line in the mean time turneth uniformly about one of its extreme points fixed, as the centre of his gyration. But because the right motion of grave bodies falling, is continually accelerated, it is necessary, that the line resulting of the com-

* This is that excellent tract which we give the first place in our second Volume.

composition of the two motions do go alwayes receding with greater and greater proportion from the circumference of that circle; which the centre of the stones gravity would have designed, if it had alwayes staid upon the Tower; it followeth of necessity that this recession at the first be but little; yea very small, yea, more, as small as can be imagined; seeing that the descending grave body departing from rest, that is; from the privation of motion; towards the bottom and entring into the right motion downwards; it must needs passe through all the degrees of tardity, that are betwixt rest, and any assigned velocity; the which degrees are infinite; as already hath been at large discoursed and proved.

It being supposed therefore, that the progresse of the acceleration being after this manner; and it being moreover true, that the descending grave body goeth to terminate in the centre of the Earth; it is necessary that the line of its mixt motion be such, that it go continually receding with greater and greater proportion from the top of the Tower, or to speak more properly, from the circumference of the circle described by the top of the Tower, by means of the Earths conversion; but that such recessions be lesser and lesser *in infinitum*; by how much the moveable finds it self to be lesse and lesse removed from the first term where it rested. Moreover it is necessary, that this line of the compounded motion do go to terminate in the centre of the Earth. Now having presupposed these two things, I come to describe about the centre A [in Fig. 1. of this second Dialogue;] with the semidiameter AB, the circle BI, representing to me the Terrestrial Globe, and prolonging the semidiameter AB to C, I have described the height of the Tower BC; the which being carried about by the Earth along the circumference BI, describeth with its top the arch CD: Dividing, in the next place, the line CA in the middle at E; upon the centre E, at the distance EC, I describe the semicircle CIA. In which, I now affirm, that it is very probable that a stone falling from the top of the Tower C, doth move, with a motion mixt of the circular, which is in common, and of its peculiar right motion. If therefore in the circumference CD, certain equal parts CF, FG, GH, HL, be marked, and from the points F, G, H, L, right lines be drawn towards the centre A, the parts of them intercepted between the two circumferences CD and BI, shall represent unto us the same Tower CB, transported by the Terrestrial Globe towards DI; in which lines the points where they come to be intersected by the arch of the semicircle CI, are the places by which from time to time the falling stone doth passe; which points go continually with greater and greater proportion receding from the top of the

T

Tower:

The line described by a moveable in its natural descent, the motion of the Earth about its own centre being presupposed, would probably be the circumference of a circle.

Tower. And this is the cause why the right motion made along the side of the Tower appeareth to us more and more accelerate. It appeareth also, how by reason of the infinite acutenesse of the contact of those two circles DC , CI , the recession of the cadent moveable from the circumference CFD , namely, from the top of the Tower, is towards the beginning extream small, which is as much as if one said its motion downwards is very slow, and more and more slow *in infinitum*, according to its vicinity to the term C , that is to the state of rest. And lastly it is seen how in the end this same motion goeth to terminate in the centre of the Earth A .

SAGR. I understand all this very well, nor can I perswade myself that the falling moveable doth describe with the centre of its gravity any other line, but such an one as this.

SALV. But stay a little, *Sagredus*, for I am to acquaint you also with three Observations of mine, that its possible will not displease you. The first of which is, that if we do well consider, the moveable moveth not really with any more than onely one motion simply circular, as when being placed upon the Tower, it moved with one single and circular motion. The second is yet more pleasant, for, it moveth neither more nor lesse then if it had staid continually upon the Tower, being that to the arches CF , FG , GH , &c. that it would have passed continuing alwayes upon the Tower, the arches of the circumference CI are exactly equal, answering under the same CF , FG , GH , &c. Whence followeth the third wonder, That the true and real motion of the stone is never accelerated, but alwayes even and uniforme, since that all the equal arches noted in the circumference CD , and their respondent ones marked in the circumference CI , are past in equal times; so that we are left at liberty to seek new causes of acceleration, or of other motions, seeing that this moveable, as well standing upon the Tower, as descending thence, alwayes moveth in the same fashion, that is, circularly, with the same velocity, and with the same uniformity. Now tell me what you think of this my fantastical conjecture.

SAGR. I must tell you, that I cannot with words sufficiently expresse how admirable it seemeth to me; and for what at present offereth it self to my understanding, I cannot think that the business happeneth otherwise; and would to God that all the demonstrations of Philosophers were but half so probable as this. However for my perfect satisfaction I would gladly hear how you prove those arches to be equal.

SALV. The demonstration is most easie. Suppose to your self a line drawn from I to E . And the Semidiameter of the circle CD , that is, the line CA , being double the Semidiameter CE of the

A moveable falling from the top of the Tower, moveth in the circumference of a circle. It moveth neither more nor lesse, than if it had staid alwayes there.

It moveth with an uniform, not an accelerate motion.

circle C I, the circumference shall be double to the circumference, and every arch of the greater circle double to every like arch of the lesser; and consequently, the half of the arch of the greater circle, equal to the whole arch of the lesser. And because the angle C E I made in the centre E of the lesser circle, and which insisteth upon the arch C I, is double the angle C A D, made in the centre A of the greater circle, to which the arch C D subtendeth; therefore the arch C D is half of the arch of the greater circle like to the arch C I, and therefore the two arches C D and C I are equal; and in the same manner we may demonstrate of all their parts. But that the business, as to the motion of descending grave bodies, proceedeth exactly thus, I will not at this time affirm; but this I will say, that if the line described by the cadent moveable be not exactly the same with this, it doth extreamly resemble the same.

SAGR. But I, *Salviatus*, am just now considering another particular very admirable; and this it is; That admitting these considerations, the right motion doth go wholly * mounting, and that Nature never makes use thereof, since that, even that that use, which was from the beginning granted to it; which was of reducing the parts of integral bodies to their place, when they were separated from their whole, and therefore constituted in a depraved disposition, is taken from it; and assigned to the circular motion.

*Right motion
seemeth wholly ex-
cluded in nature.
* Vadia del tutto a
monte, rendered in
the Latine omni-
no possum cat.*

SALV. This would necessarily follow, if it were concluded that the Terrestrial Globe moveth circularly; a thing, which I pretend not to be done, but have onely hitherto attempted, as I shall still, to examine the strength of those reasons, which have been alledged by Philosophers to prove the immobility of the Earth, of which this first taken from things falling perpendicularly, hath begat the doubts; that have been mentioned; which I know not of what force they may have seemed to *Simplicius*; and therefore before I passe to the examination of the remaining arguments, it would be convenient that he produce what he hath to reply to the contrary.

SIMP. As to this first, I confesse indeed that I have heard sundry pretty notions; which I never thought upon before, and in regard they are new unto me, I cannot have answers so ready for them, but this argument taken from things falling perpendicularly, I esteem it not one of the strongest proofs of the mobility of the Earth; and I know not what may happen touching the shots of great Guns, especially those aimed contrary to the diurnal motion.

SAGR. The flying of the birds as much puzzleth me as the objection of the Gun-shot, and all the other experiments above

alledged. For these birds which at their pleasure flie forwards and backwards, and wind to and again in a thousand fashions, and, which more importeth, lie whole hours upon the wing, these I say do not a little pose me, nor do I see, how amongst so many circumgyrations, they should not lose the motion of the Earth, and how they should be able to keep pace with so great a velocity as that which they so far exceed with their flight.

SALV. To speak the truth, your scruple is not without reason, and its possible. *Copernicus* himself could not find an answer for it, that was to himself entirely satisfactory; and therefore haply past it over in silence; albeit he was, indeed, very brief in examining the other allegations of his adversaries; I believe through his height of wit, placed on greater and sublimer contemplations, like as Lions are not much moved at the barking of little Dogs. We will therefore reserve the instance of birds to the last place, and for the present, see if we can give *Simplicius* satisfaction in the others, by shewing him in our wonted manner, that he himself hath their answers at hand; though upon first thoughts he doth not discover them. And to begin with the shots made at random, with the self same piece, powder, and ball, the one towards East, the other towards the West (if the diurnal conversion belonged to the Earth) ought to be much longer than that towards East.

SIMP. I am moved so to think; because in the shot made towards the East, the ball whilst it is out of the piece, is followed by the said piece, the which being carried round by the Earth, runneth also with much velocity towards the same part, where upon the fall of the ball to the ground, cometh to be but little distant from the piece. On the contrary in the shot towards the West, before that the ball falleth to the ground, the piece is retired very far towards the East; by which means the space between the ball and the piece, that is Range, will appear longer than the other, by how much the piece, that is the Earth, had run in the time that both the balls were in the air.

SALV. I could wish, that we did know some way to make an experiment corresponding to the motion of these projects, as that of the ship doth to the motion of things perpendicularly falling from on high; and I am thinking how it may be done.

SAGR. I believe, that it would be a very opposite proof, to take an open Chariot, and to accomodate therein a *Stock-bow at half elevation, to the end the flight may prove the greatest that may be, and whilst the horses shall run, to shoot first towards the part whither you drive, and then another backwards towards the contrary part, causing some one to mark diligently where the Chariot was in that moment of time when the shaft came to the

*The reason why
a Gun should seem
to carry farther to-
wards the West
than towards the
East.*

*The experiment
of a running cha-
riot to find out the
difference of Ran-
ges.
*Balestrone da bol-
zoni.*

the ground, as well in the one shot as in the other : for thus you may see exactly how much one shaft flew farther than the other.

SIMP. In my thoughts this experiment is very proper : and I do not doubt but that the flight, that is, the space between the shaft and the place where the chariot was at the shafts fall, will be less by much when one shooteth towards the chariots course, than when one shooteth the contrary way. For an example, let the flight of it self be three hundred yards, and the course of the chariot in the time, whilst the shaft stayeth in the air, an hundred yards, therefore shooting towards the course of the three hundred yards of the flight, the chariot will have gone one hundred, so then at the shafts coming to the ground, the space between it and the chariot, shall be but two hundred yards onely ; but on the contrary, in the other shoot, the chariot running contrary to the shaft, when the shaft shall have passed its three hundred yards, and the chariot its other hundred the contrary way, the distance interposing shall be found to be four hundred yards.

SALV. Is there any way to shoot so that these flights may be equal ?

SIMP. I know no other way, unless by making the chariot to stand still.

SALV. This we know ; but I mean when the chariot runneth in full career.

SIMP. In that case you are to draw the Bow higher in shooting forwards, and to slack it in shooting the contrary way.

SALV. Then you see that there is one way more. But how much is the bow to be drawn, and how much slackened ?

SIMP. In our case, where we have supposed that the bow carried three hundred yards, it would be requisite to draw it so, as that it might carry four hundred, and in the other to slacken it so, as that it might carry no more than two hundred. For so each of the flights would be but three hundred in relation to the chariot, the which, with its course of an hundred yards which it subtracts from the shoot of four hundred, and addeth to that of two hundred, would reduce them both to three hundred.

SALV. But what effect hath the greater or less intensness of the bow upon the shaft ?

SIMP. The stiffer bow carrieth it with greater velocity, and the weaker with less ; and the same shaft flieth so much farther at one time than another, with how much greater velocity it goeth out of the tiller at one time, than another.

SALV. So that to make the shaft shot either way, to flie at equal distance from the running chariot, it is requisite, that if in the first shoot of the precedent example, it goeth out of the tiller with v. g. four degrees of velocity, that then in the other shoot it depart

part but with two onely : but if the same bow be used, it always receiveth thence three degrees.

SIMP. It doth so; and for this reason, shooting with the same bow in the chariots course, the shoots cannot be equal.

SALV. I had forgot to ask, with what velocity it is supposed in this particular experiment, that the chariot runneth.

SIMP. The velocity of the chariot must be supposed to be one degree in comparison to that of the bow, which is three,

SALV. Very right, for so computation gives it. But tell me, when the chariot moveth, doth not all things in the same move with the same velocity?

SIMP. Yes doubtless.

SALV. Then so doth the shaft also, and the bow, and the string, upon which the shaft is nock't.

SIMP. They do so.

SALV. Why then, in discharging the shaft towards the course of the chariot, the bow impresseth its three degrees of velocity on a shaft that had one degree of velocity before, by means of the chariot which transported it so fast towards that part; so that in its going off it hath four degrees of velocity. On the contrary, in the other shoot, the same bow conferreth its same three degrees of velocity on a shaft that moveth the contrary way, with one degree; so that in its departing from the bow-string, it hath no more left but onely two degrees of velocity. But you your self have already said, that the way to make the shoots equal, is to cause that the shaft be let flie the first time with four degrees of velocity, and the second time with two. Therefore without changing the bow, the very course of the chariot is that which adjusteth the flights, and the experiment doth so represent them to any one who is not either wilfully or naturally incapable of reason. Now apply this discourse to Gunnery, and you shall find, that whether the Earth move or stand still, the shots made with the same force, will always curie equal ranges, to what part soever aimed. The error of Aristotle, Ptolomey, Tycho, your self, and all the rest, is grounded upon that fixed and strong persuasion, that the Earth standeth still, which you have not judgment nor power to depose, no not when you have a desire to argue of that which would ensue, presupposing the Earth to move. And thus, in the other argument, not considering that whil'st the stone is upon the Tower, it doth, as to moving or not moving, the same that the Terrestrial Globe doth, because you have concluded with your self, that the Earth stands still, you always discourse touching the fall of the stone, as if it were to depart from rest: whereas it behooveth to say, that if the Earth standeth still, the stone departeth from rest, and descendeth perpendicularly; but if the Earth do move, the stone likewise

*The solution of
the argument ta-
ken from great-
Guns shot towards
the East & West.*

likewise moveth with like velocity, nor doth it depart from rest, but from a motion equal to that of the Earth, wherewith it intermixeth the supervenient motion of descent, and of those two compositeth a third which is transversal or side-ways.

SIMP. But for Gods sake, if it move transversely, how is it that I behold it to move directly and perpendicularly? This is no better than the denial of manifest sense; and if we may not believe sense, at what other door shall we enter into disquisitions of Philosophy?

SALV. In respect to the Earth, to the Tower, and to our selves, which all as one piece move with the diurnal motion together with the stone, the diurnal motion is as if it never had been, and becometh insensible, imperceptible, and without any action at all; and the onely motion which we can perceive, is that of which we partake not, that is the descent gliding along the side of the Tower: You are not the first that hath felt great repugnance in apprehending this non-operating of motion upon things to which it is common.

SAGR. Now I do remember a certain conceipt, that came one day into my fancy, whilst I sailed in my voyage to Aleppo, whither I went Consul for our Countrey, and possibly it may be of some use, for explaining this nullity of operation of common motion, and being as if it never were to all the partakers thereof. And if it stand with the good liking of *Simplicius*, I will reason with him upon that which then I thought of by my self alone.

SIMP. The novelty of the things which I hear, makes me not so much a patient, as a greedy and curious auditor: therefore go on.

SAGR. If the neb of a writing pen, that I carried along with me in the ship, through all my navigation from Venice to *Scanderon*, had had a facultie of leaving visible marks of its whole voyage, what signs, what marks, what lines would it have left?

SIMP. It would have left a line distended from Venice thither, not perfectly streight, or to say better, distended in a perfect arch of a circle, but in some places more, in some less curved, according as the vessel had gone more or less fluctuating; but this its inflecting in some places a fathom or two to the right hand or to the left, upwards or downwards, in a length of many hundred miles, would have brought but little alteration to the intire tract of the line, so that it would have been hardly sensible; and without any considerable error, might have been called the part of a perfect arch.

SAGR. So that the true and most exact motion of the neb of my pen would have also been an arch of a perfect circle, if the vessels motion, the fluctiation of the billows ceasing, had been calm

A notable case of Sagredus, to shew the non-operating of common motion.

** Alefsandretta.*

calm and tranquill. And if I had continually held that pen in my hand, and had onely moved it sometimes an inch or two this way or that way, what alteration should I have made in that its principal, and very long tract or stroke?

SIMP. Less than that which the declining in several places from absolute rectitude, but the quantity of a flea's eye makes in a right line of a thousand yards long.

SAGR. If a Painter, then, at our launching from the Port, had began to design upon a paper with that pen, and continued his work till he came to *Scanderon*, he would have been able to have taken by its motion a perfect draught of all those figures perfectly interwoven and shadowed on several sides with countreys, buildings, living creatures, and other things; albeit all the true, real, and essential motion traced out by the neb of that pen, would have been no other than a very long, but simple line: and as to the proper operation of the Painter, he would have delineated the same to an hair, if the ship had stood still. That therefore of the huge long motion of the pen there doth remain no other marks, than those tracks drawn upon the paper, the reason thereof is because the grand motion from *Venice* to *Scanderon*, was common to the paper, the pen, and all that which was in the ship: but the petty motions forwards and backwards, to the right, to the left, communicated by the fingers of the Painter unto the pen, and not to the paper, as being peculiar thereunto, might leave marks of it self upon the paper, which did not move with that motion. Thus it is likewise true, that the Earth moving, the motion of the stone in descending downwards, was really a long tract of many hundreds and thousands of yards, and if it could have been able to have delineated in a calm air, or other superficies, the track of its course, it would have left behind an huge long transverse line. But that part of all this motion which is common to the stone, the Tower, and our selves, is imperceptible to us, and as if it had never been, and that part onely remaineth observable, of which neither the Tower nor we are partakers, which is in fine, that wherewith the stone falling measureth the Tower.

SALV. A most witty conceipt to clear up this point, which was not a little difficult to many capacities. Now if *Simplicius* will make no farther reply, we may pass to the other experiments, the unfolding of which will receive no small facility from the things already declared.

SIMP. I have nothing more to say: and I was well-nigh transported with that delineation, and with thinking how those strokes drawn so many ways, hither, thither, upwards, downwards, forwards, backwards, and interwoven with thousands of turnings, are not essentially or really other, than small pieces of one sole line drawn

drawn all one way, and the same without any other alteration save the declining the direct rectitude, sometimes a very insensible matter towards one side or another, and the pens moving its neb one while softer, another while slower, but with very small inequality. And I think that it would in the same manner write a letter, and that those froolike penmen, who to shew their command of hand, without taking their pen from the paper in one sole stroke, with infinite turnings draw a pleasant knot, if they were in a boat that did tide it along swiftly they would convert the whole motion of the pen, which in reality is but one sole line, drawn all towards one and the same part, and very little curved, or declining from perfect rectitude, into a knot or flourish. And I am much pleased that *Sagredus* hath helped me to this conceit: therefore let us go on, for the hope of meeting with more of them, will make me the stricter in my attention.

SAGR. If you have a curiosity to hear such like subtilties, which occur not thus to every one, you will find no want of them, especially in this particular of Navigation; and do you not think that a witty conceit which I met with likewise in the same voyage, when I observed that the mast of the ship, without either breaking or bending, had made a greater voyage with its round-top, that is with its top-gallant, than with its foot; for the round top being more distant from the centre of the Earth than the foot is, it had described the arch of a circle bigger than the circle by which the foot had passed.

SIMP. And thus when a man walketh he goeth farther with his head than with his feet.

SAGR. You have found out the matter your self by help of your own mother-vvit: But let us not interrupt *Salviatus*.

SALV. It pleaseth me to see *Simplicius* how he sootheth up himself in this conceit, if happily it be his own, and that he hath not borrowed it from a certain little pamphlet of conclusions, where there are a great many more such fancies no less pleasant & witty. It followeth that we speak of the peice of Ordinance mounted perpendicular to the Horizon, that is, of a shot towards our vertical point, and to conclude, of the return of the ball by the same line unto the same peice, though that in the long time which it is separated from the peice, the earth hath transported it many miles towards the East; now it seemeth, that the ball ought to fall a like distance from the peice towards the West; the which doth not happen: therefore the peice without having been moved did stay expecting the same. The answer is the same with that of the stone falling from the Tower; and all the fallacy, and equivocation consisteth in supposing still for true, that which is in question; for the Opponent hath it still fixed in his conceit that the ball departs from its rest, being discharged by the fire

Subtilties sufficiently insipid, ironically, spoken and taken from a certain Encyclopædia.

An instance against the diurnal motion of the earth, taken from the shot of a Peice of Ordinance perpendicularly.

The answer to the objection, showing the equivoke.

V

from the piece; and the departing from the state of rest, cannot be, unless the immobility of the Terrestrial Globe be presupposed, which is the conclusion of that was in dispute; Therefore, I reply, that those who make the Earth moveable, answer, that the piece, and the ball that is in it, partake of the same motion with the Earth; nay that they have this together with her from nature; and that therefore the ball departs in no other manner from its quiescence, but conjoyned with its motion about the centre; the which by its projection upwards, is neither taken away, nor hindered; and in this manner following, the universal motion of the Earth towards the East, it alwayes keepeth perpendicular over the said piece, as well in its rise as in its return. And the same you see to ensue, in making the experiment in a ship with a bullet shot upwards perpendicularly with a Crosse-bow, which returneth to the same place whether the ship doth move, or stand still.

Another answer
to the same objection.

SAGR. This satisfieth very well to all; but because that I have seen that *Simplicius* rakech pleasure with certain subtilties to puzzle his companions, I will demand of him whether, supposing for this time that the Earth standeth still, and the piece erected upon it perpendicularly, directed to our Zenith, he do at all question that to be the true perpendicular shot, and that the ball in departing, and in its return is to go by the same right line, still supposing all external and accidental impediments to be removed.

SIMP. I understand that the matter ought to succeed exactly in that manner.

SAGR. But if the piece were placed, not perpendicularly, but inclining towards some place, what would the motion of the ball be? Would it go haply, as in the other shot, by the perpendicular line, and return again by the same?

SIMP. It would not so do; but issuing out of the piece, it would pursue its motion by a right line which prolongeth the erect perpendicularity of the concave cylinder of the piece, unless so far as its own weight would make it decline from that erection towards the Earth.

SAGR. So that the mounture of the cylinder is the regulator of the motion of the ball; nor doth it, or would it move out of that line, if its own gravity did not make it decline downwards. And therefore placing the cylinder perpendicularly, and shooting the ball upwards, it returneth by the same right line downwards; because the motion of the ball dependent on its gravity is downward, by the same perpendicular. The journey therefore of the ball out of the piece, continueth or prolongeth the rectitude or perpendicularity of that small part of the said journey, which is made within the said piece; is it not so?

SIMP.

Projects continue their motion by the right line that followeth the direction of the motion, made together with the project, whilst they were conjoyn'd therewith.

SIMP. So it is, in my opinion.

SAGR. Now imagine the cylinder to be erected, and that the Earth doth revolve about vwith a diurnal motion, carrying the piece along vwith it; tell me vwhat shall be the motion of the ball vwithin the cylinder, having given fire?

SIMP. It shall be a streight and perpendicular motion, the cylinder being erected perpendicularly.

SAGR. Consider vwell vwhat you say: for I believe that it vwill not be perpendicular. It vwould indeed be perpendicular, if the Earth stood still, for so the ball vwould have no other motion but that proceeding from the fire. But in case the Earth turns round, the ball that is in the piece, hath likewise a diurnal motion; so that there being added to the same the impulse of the fire; it moveth from the breech of the piece to the muzzle with two motions, from the composition whereof it cometh to passe that the motion made by the centre of the balls gravity is an inclining line. And for your clearer understanding the same; let the piece AC [in Fig. 2.] be erected, and in it the ball B; it is manifest, that the piece standing immoveable, and fire being given to it, the ball will make its way out by the mouth A, and with its centre, passing thorow the the piece, shall have described the perpendicular line BA, and it shall pursue that rectitude when it is out of the piece, moving toward the Zenith. But in case the Earth should move round, and consequently carry the piece along with it, in the time that the ball driven out of the piece shall move along the cylinder, the piece being carried by the Earth, shall passe into the situation DE, and the ball B, in going off, would be at the cornish D, and the motion of the balls centre; would have been according to the line BD, no longer perpendicular, but inclining towards the East; and the ball (as hath been concluded) being to continue its motion through the air, according to the direction of the motion made in the piece, the said motion shall continue on according to the inclination of the line BD, and so shall no longer be perpendicular, but inclined towards the East, to which part the piece doth also move; whereupon the ball may follow the motion of the Earth, and of the piece. Now *Simplicius*; you see it demonstrated; that the Range which you took to be perpendicular, is not so.

SIMP. I do not very well understand this business; do you, *Salvatus*?

SALV. I apprehend it in part; but I have a certain kind of scruple, which I wish I knew how to express. It seems to me, that according to what hath been said, if the Piece be erected perpendicular, and the Earth do move, the ball would not be to fall, as *Aristotle* and *Tycho* will have it, far from the Piece towards the

V 2

West,

The revolution of the Earth supposed, the ball in the piece erected perpendicularly, doth not move by a perpendicular, but an inclined line.

West, nor as you would have it, upon the Piece, but rather far distant towards the East. For according to your explanation, it would have two motions, the which would with one consent carry it thitherward, to wit, the common motion of the Earth, which carrieth the Piece and the ball from C A towards E D; and the fire which carrieth it by the inclined line B D, both motions towards the East, and therefore they are superiour to the motion of the Earth.

SAGR. Not so, Sir. The motion which carrieth the ball towards the East, cometh all from the Earth, and the fire hath no part at all therein: the motion which mounteth the ball upwards, is wholly of fire, wherewith the Earth hath nothing to do. And that it is so, if you give not fire, the ball will never go out of the Piece, nor yet rise upwards a hairs breadth; as also if you make the Earth immoveable, and give fire, the ball without any inclination shall go perpendicularly upwards. The ball therefore having two motions, one upwards, and the other in gyration, of both which the transverse line B D is compounded, the impulse upward is wholly of fire, the circular cometh wholly from the Earth, and is equal to the Earths motion: and being equal to it, the ball maintaineth it self all the way directly over the mouth of the Piece, and at last fallerh back into the same: and because it always observeth the erection of the Piece, it appeareth also continually over the head of him that is near the Piece, and therefore it appeareth to mount exactly perpendicular towards our Zenith, or vertical point.

SIMP. I have yet one doubt more remaining, and it is, that in regard the motion of the ball is very swift in the Piece, it seems not possible, that in that moment of time the transposition of the Piece, from C A to A D should confer such an inclination upon the transverse line C D, that by means thereof, the ball when it cometh afterwards into the air should be able to follow the course of the Earth.

SAGR. You err upon many accounts; and first, the inclination of the transverse line C D, I believe it is much greater than you take it to be, for I verily think that the velocity of the Earths motion, not onely under the Equinoctial, but in our paralel also, is greater than that of the ball whilst it moveth in the Piece; so that the interval C E would be absolutely much bigger than the whole length of the Piece, and the inclination of the transverse line consequently bigger than half a right angle: but be the velocity of the Earth more, or be it less, in comparison of the velocity of the fire, this imports nothing; for if the velocity of the Earth be small, and consequently the inclination of the transverse line be little also; there is then also need but of little inclination to make the ball

ball suspend it self in its range directly over the Piece. And in a word, if you do but attentively consider, you will comprehend, that the motion of the Earth in transferring the Piece along with it from C A to E D, conferreth upon the transverse line C D, so much of little or great inclination, as is required to adjust the range to its perpendicularity. But you err, secondly, in that you refer the faculty of carrying the ball along with the Earth to the impulse of the fire, and you run into the same error, into which *Salviatus*, but even now seemed to have fallen; for the faculty of following the motion of the Earth, is the primary and perpetual motion, indelibly and inseparably imparted to the said ball, as to a thing terrestrial, and that of its own nature doth and ever shall possess the same.

SALV. Let us yield, *Simplicius*, for the business is just as he saith. And now from this discourse let us come to understand the reason of a Venatorian Problem, of those Fowlers who with their guns shoot a bird flying; and because I did imagine, that in regard the bird flieth a great pace, therefore they should aim their shot far from the bird, anticipating its flight for a certain space, and more or less according to its velocity and the distance of the bird, that so the bullet hasting directly to the mark aimed at, it might come to arrive at the self same time in the same point with its motion, and the bird with its flight, and by that means one to encounter the other: and asking one of them, if their practise was not so to do; He told me, no; but that the flight was very easie and certain, and that they took aim just in the same manner as if they had shot at a bird that did sit still; that is, they made the flying bird their mark, and by moving their fowling-piece they followed her, keeping their aim still full upon her, till such time as they let fly, and in this manner shot her as they did others sitting still. It is necessary therefore that that motion, though slow, which the fowling-piece maketh in turning and following after the flight of the bird do communicate it self to the bullet also, and that it be joyned with that of the fire; so that the ball hath from the fire the motion directly upwards, and from the concave Cylinder of the barrel the declination according to the flight of the Bird, just as was said before of the shot of a Canon; where the ball receiveth from the fire a virtue of mounting upwards towards the Zenith, and from the motion of the Earth its winding towards the East, and of both maketh a compound motion that followeth the course of the Earth, and that to the beholder seemeth onely to go directly upwards, and return again downwards by the same line. The holding therefore of the gun continually directed towards the mark, maketh the shoot hit right, and that you may keep your gun directed to the mark, in case the mark stands still, you must also hold your

The manner how
Fowlers shoot birds
flying.

*The answer to
the objection taken
from the shots of
great Guns made
towards the North
and South.*

your gun still; and if the mark shall move, the gun must be kept upon the mark by moving. And upon this dependeth the proper answer to the other argument taken from the shot of a Canon, at the mark placed towards the South or North: wherein is alledged, that if the Earth should move, the shots would all range Westward of the mark, because that in the time whilst the ball, being forc'd out of the Piece, goeth through the air to the mark, the said mark being carried toward the East, would leave the ball to the Westward. I answer therefore, demanding whether if the Canon be aimed true at the mark, and permitted so to continue, it will constantly hit the said mark, whether the Earth move or stand still? It must be replied, that the aim altereth not at all, for if the mark doth stand still, the Piece also doth stand still, and if it, being transported by the Earths motion, doth move, the Piece doth also move at the same rate, and, the aim maintained, the shot proveth always true, as by what hath been said above, is manifest.

SAGR. Stay a little, I entreat you, *Salviatus*, till I have propounded a certain conceit touching these shooters of birds flying, whose proceeding I believe to be the same which you relate, and believe the effect of hitting the bird doth likewise follow: but yet I cannot think that act altogether conformable to this of shooting in great Guns, which ought to hit as well when the piece and mark moveth, as when they both stand still; and these, in my opinion, are the particulars, in which they disagree. In shooting with a great Gun both it and the mark move with equal velocity, being both transported by the motion of the Terrestrial Globe: and albeit sometimes the piece being planted more towards the Pole, than the mark, and consequently its motion being somewhat slower than the motion of the mark, as being made in a lesser circle, such a difference is insensible, at that little distance of the piece from the mark: but in the shot of the Fowler the motion of the Fowling-piece wherewith it goeth following the bird, is very slow in comparison of the flight of the said bird; whence me thinks it should follow, that that small motion which the turning of the Birding-piece conferreth on the bullet that is within it, cannot, when it is once gone forth of it, multiply it self in the air, untill it come to equal the velocity of the birds flight, so as that the said bullet should always keep direct upon it: nay, me thinketh the bird would anticipate it and leave it behind. Let me add, that in this act, the air through which the bullet is to pass, partaketh not of the motion of the bird: whereas in the case of the Canon, both it, the mark, and the intermediate air, do equally partake of the common diurnal motion. So that the true cause of the Marks-man his hitting the mark, as it should seem, moreover and besides the following

following the birds flight with the piece, is his somewhat anticipat-
ing it, taking his aim before it; as also his shooting (as I believe)
not with one bullet, but with many small balls (called shot) the
which scattering in the air possess a great space; and also the ex-
treme velocity wherewith these shot, being discharged from the
Gun, go towards the bird.

SALV. See how far the winged wit of *Sagredus* anticipateth,
and out-goeth the dulness of mine; which perhaps would have
light upon these disparities, but not without long studie. Now
turning to the matter in hand, there do remain to be considered
by us the shots at point blank, towards the East and towards the
West; the first of which, if the Earth did move, would always
happen to be too high above the mark, and the second too low;
forasmuch as the parts of the Earth Eastward, by reason of the di-
urnal motion, do continually descend beneath the tangent paralel
to the Horizon, whereupon the Eastern stars to us appear to ascend;
and on the contrary, the parts Westward do more and more as-
cend, whereupon the Western stars do in our seeming descend:
and therefore the ranges which are leveled according to the said
tangent at the Oriental mark, (which whilst the ball passeth
along by the tangent descendeth) should prove too high, and the
Occidental too low by means of the elevation of the mark, whilst
the ball passeth along the tangent. The answer is like to the rest:
for as the Eastern mark goeth continually descending, by reason
of the Earths motion, under a tangent that continueth immove-
able; so likewise the piece for the same reason goeth continually
inclining, and with its mounture pursuing the said mark: by
which means the shot proveth true.

But here I think it a convenient opportunity to give notice of
certain concessions, which are granted perhaps over liberally by
the followers of *Copernicus* unto their Adversaries: I mean of
yielding to them certain experiments for sure and certain, which
yet the Adversaries themselves had never made tryal of: as for
example, that of things falling from the round-top of a ship whilst
it is in motion, and many others; amongst which I verily believe,
that this of experimenting whether the shot made by a Canon to-
wards the East proveth too high, and the Western shot too low,
is one: and because I believe that they have never made tryal
thereof, I desire that they would tell me what difference they
think ought to happen between the said shots, supposing the Earth
moveable, or supposing it moveable; and let *Simplicius* for this
time answer for them.

SIMP. I will not undertake to answer so confidently as another
more intelligent perhaps might do; but shall speak what thus upon
the sudden I think they would reply; which is in effect the same
with

*The answer to the
Argument taken
from the shots at
point blank to-
wards the East &
West.*

*The followers of
Copernicus too
freely admit cer-
tain propositions for
true, which are
very doubtful.*

with that which hath been said already, namely, that in case the Earth should move, the shots made Eastward would prove too high, &c. the ball, as it is probable, being to move along the tangent.

SALV. But if I should say, that so it falleth out upon triall, how would you censure me?

SIMP. It is necessary to proceed to experiments for the proving of it.

SALV. But do you think, that there is to be found a Gunner so skilful, as to hit the mark at every shoot, in a distance of v.g. five hundred paces?

SIMP. No Sir; nay I believe that there is no one, how good a marks-man soever that would promise to come within a pace of the mark,

SALV. How can we then, with shots so uncertain, assure ourselves of that which is in dispute?

SIMP. We may be assured thereof two wayes; one, by making many shots; the other, because in respect of the great velocity of the Earths motion, the deviation from the mark would in my opinion be very great.

SALV. Very great, that is more than one pace; in regard that the varying so much, yea and more, is granted to happen ordinarily even in the Earths mobility.

SIMP. I verily believe the variation from the mark would be more than so.

*A Computation
how much the ranges
of great shot
ought to vary from
the marks, the
Earths motion being
granted.*

SALV. Now I desire that for our satisfaction we do make thus in grosse a slight calculation, if you consent thereto, which will stand us in stead likewise (if the computation succeed as I expect) for a warning how we do in other occurrences suffer our selves, as the saying is, to be taken with the enemies shouts, and surrender up our belief to what ever first presents it self to our fancy. And now to give all advantages to the *Peripateticks* and *Tychonicks*, let us suppose our selves to be under the Equinoctial, there to shoot a piece of Ordinance point blank Eastwards at a mark five hundred paces off. First, let us see thus (as I said) in a level, what time the shot after it is gone out of the Piece taketh to arrive at the mark; which we know to be very little, and is certainly no more than that wherein a travailer walketh two steps, which also is less than the second of a minute of an hour; for supposing that the travailer walketh three miles in an hour, which are nine thousand paces, being that an hour containes three thousand, six hundred second minutes, the travailer walketh two steps and an half in a second, a second therefore is more than the time of the balls motion. And for that the diurnal revolution is twenty four hours, the Western horizon riseth fifteen degrees in an hour, that is,

is, fifteen first minutes of a degree, in one first minute of an hour; that is, fifteen seconds of a degree, in one second of an hour; and because one second is the time of the shot, therefore in this time the Western horizon riseth fifteen seconds of a degree, and so much likewise the mark; and therefore fifteen seconds of that circle, whose semidiameter is five hundred paces (for so much the distance of the mark from the Piece was supposed.) Now let us look in the table of Arches and Chords (see here is *Copernicus* his book) what part is the chord of fifteen seconds of the semidiameter, that is, five hundred paces. Here you see the chord (or subtense) of a first minute to be less than thirty of those parts, of which the semidiameter is an hundred thousand. Therefore the chord of a second minute shall be less then half of one of those parts, that is less than one of those parts, of which the semidiameter is two hundred thousand; and therefore the chord of fifteen seconds shall be less than fifteen of those same two hundred thousand parts; but that which is less than (a) fifteen parts of two hundred thousand, is also more than that which is four centesimes of five hundred; therefore the ascent of the mark in the time of the balls motion is lesse than four centesimes, that is, than one twenty fifth part of a pace; it shall be therefore (b) about two inches: And so much consequently shall be the variation of each Western shot, the Earth being supposed to have a diurnal motion. Now if I shall tell you, that this variation (I mean of falling two inches short of what they would do in case the Earth did not move) upon triall doth happen in all shots, how will you convince me *Simplicius*, shewing me by an experiment that it is not so? Do you not see that it is impossible to confute me, unless you first find out a way to shoot at a mark with so much exactnesse, as never to misse an hairs bredth? For whilst the ranges of great shot consist of different numbers of paces, as *de facto* they do, I will affirm that in each of those variations there is contained that of two inches caused by the motion of the Earth.

SAGR. Pardon me, *Salviatus*, you are too liberal. For I would tell the *Peripateticks*, that though every shot should hit the very centre of the mark, that should not in the least disprove the motion of the Earth. For the Gunners are so constantly employed in levelling the sight and gun to the mark, as that they can hit the same, notwithstanding the motion of the Earth. And I say, that if the Earth should stand still, the shots would not prove true; but the Occidental would be too low, and the Oriental too high: now let *Simplicius* disprove me if he can.

SALV. This is a subtilty worthy of *Sagredus*: But whether this variation be to be observed in the motion, or in the rest of the Earth, it must needs be very small, it must needs be swallowed up

X

in

(a) That is, in plainer termes the fraction $\frac{15}{200000}$, is more than the fraction $\frac{4}{100000}$, for dividing the denominators by their nominators, and the first produceth 13333 $\frac{1}{3}$; the other but 12500.

(b) It shall be neer 2 $\frac{1}{2}$ inches, accounting the pace to be Geometrical, containing 5 foot.

It is demonstrated with great subtilty, that the Earths motion supposed, Canon shots ought not to vary more than in rest.

It is requisite to be very cautious in admitting experiments for true, to those who never tried them.

Experiments and arguments against the Earths motion seem so far concluding, as they lie hid under equivokes.

in those very great ones which sundry accidents continually produce. And all this hath been spoken and granted on good grounds, to *Simplicius*, and only with an intent to advertise him how much it importeth to be cautious in granting many experiments for true to those who never had tried them, but only eagerly alledged them just as they ought to be for the serving their purpose: This is spoken, I say, by way of surplussage and Corollary to *Simplicius*, for the real truth is, that as concerning these shots, the same ought exactly to befall aswell in the motion as in the rest of the Terrestrial Globe; as likewise it will happen in all the other experiments that either have been or can be produced, which have at first blush so much semblance of truth, as the antiquated opinion of the Earths motion hath of equivocation.

SAGR. As for my part I am fully satisfied, and very well understand that who so shall imprint in his fancy this general community of the diurnal conversion amongst all things Terrestrial, to all which it naturally agreeth, aswell as in the old conceit of its rest about the centre, shall doubtlesse discern the fallacy and equivoke which made the arguments produced seem concluding. There yet remains in me some hæsitancy (as I have hinted before) touching the flight of birds; the which having as it were an animate faculty of moving at their pleasure with a thousand motions, and to stay long in the Air separated from the Earth, and therein with most irregular windings to go fluttering to and again, I cannot conceive how amongst so great a confusion of motions, they should be able to retain the first commune motion; and in what manner, having once made any stay behind, they can get it up again, and overtake the same with flying, and keep pace with the Towers and trees which hurry with so precipitant a course towards the East; I say so precipitant, for in the great circle of the Globe it is little lesse than a thousand miles an hour, whereof the flight of the swallow I believe makes not fifty.

SALV. If the birds were to keep pace with the course of the trees by help of their wings, they would of necessity flie very fast; and if they were deprived of the universal conversion, they would lag as far behind; and their flight would seem as furious towards the West, and to him that could discern the same, it would much exceed the flight of an arrow; but I think we could not be able to perceive it, no more than we see a Canon bullet, whilst driven by the fury of the fire, it flieth through the Air: But the truth is that the proper motion of birds, I mean of their flight, hath nothing to do with the universal motion, to which it is neither an help, nor an hinderance; and that which maintaineth the said motion unaltered in the birds, is the Air it self, thorough which they flie, which naturally following the *Vertigo* of the Earth

Earth, like as it carrieth the clouds along with it, so it transporteth birds and every thing else which is pendent in the same; in so much that as to the businesse of keeping pace vvith the Earth, the birds need take no care thereof, but for that work might sleep perpetually.

SAGR. That the Air can carry the clouds along with it, as being matters easie for their lightnesse to be moved and deprived of all other contrary inclination, yea more, as being matters that partake also of the conditions and properties of the Earth; I comprehend without any difficulty; but that birds, which as having life, may move with a motion quite contrary to the diurnal, once having surceased the said motion, the Air should restore them to it, seems to me a little strange, and the rather for that they are solid and weighty bodies; and withal, we see; as hath been said, stones and other grave bodies to lie unmoved against the *impetus* of the air; and when they suffer themselves to be overcome thereby, they never acquire so much velocity as the wind which carrieth them.

SALV. We ascribe not so little force, *Sagredus*, to the moved Air; which is able to move and bear before it ships full fraught, to tear up trees by the roots, and overthrow Towers when it moveth swiftly; and yet we cannot say that the motion of the Air in these violent operations is neer so violent, as that of the diurnal revolution.

SIMP. You see then that the moved Air may also continue the motion of projects, according to the Doctrine of *Aristotle*; and it seemed to me very strange that he should have erred in this particular.

SALV. It may without doubt, in case it could continue it self, but like as when the wind ceasing neither ships go on, nor trees are blown down; so the motion in the Air not continuing after the stone is gone out of the hand, and the Air ceasing to move, it followeth that it must be something else besides the Air that maketh the projects to move.

SIMP. But how upon the winds being laid, doth the ship cease to move? Nay you may see that when the wind is down, and the sails furl'd, the vessel continueth to run whole miles.

SALV. But this maketh against your self *Simplicius*, for that the wind being laid that filling the sails drove on the ship, yet nevertheless doth it without help of the *medium* continue its course.

SIMP. It might be said that the water was the *medium* which carried forward the ship, and maintain'd it in motion.

SALV. It might indeed be so affirmed, if you would speak quite contrary to truth; for the truth is, that the water, by reason

son of its great resistance to the division made by the hull of the ship, doth with great noise resist the same; nor doth it permit it of a great while to acquire that velocity which the wind would confer upon it, were the obstacle of the water removed. Perhaps *Simplicius* you have never considered with what fury the water befalls a bark, whilst it forceth its way through a standing water by help of Oars or Sails: for if you had ever minded that effect, you would not now have produced such an absurdity. And I am thinking that you have hitherto been one of those who to find out how such things succeed, and to come to the knowledge of natural effects, do not betake themselves to a Ship, a Crosse-bow, or a piece of Ordinance, but retire into their studies, and turn over Indexes and Tables to see whether *Aristotle* hath spoken any thing thereof; and being assured of the true sense of the Text, neither desire nor care for knowing any more.

The great felicity for which they are much to be envied who persuade themselves that they know every thing.

SAGR. This is a great felicity, and they are to be much envied for it. For if knowledge be desired by all, and if to be wise, be to think ones self so, they enjoy a very great happiness, for that they may persuade themselves that they know and understand all things, in scorn of those who knowing, that they understand not what these think they understand, and consequently seeking that they know not the very least particle of what is knowable, kill themselves with waking and studying, and consume their days in experiments and observations. But pray you let us return to our birds; touching which you have said, that the Air being moved with great velocity, might restore unto them that part of the diurnal motion which amongst the windings of their flight they might have lost; to which I reply, that the agitated Air seemeth unable to confer on a solid and grave body, so great a velocity as its own: And because that of the Air is as great as that of the Earth, I cannot think that the Air is able to make good the loss of the birds retardation in flight.

SALV. Your discourse hath in it much of probability, and to stick at trivial doubts is not for an acute-wit; yet nevertheless the probability being removed, I believed that it hath not a jot more force than the others already considered and resolved.

SAGR. It is most certain that if it be not necessarily conclusive, its efficacy must needs be just nothing at all. for it is only when the conclusion is necessary that the opponent hath nothing to alledge on the contrary.

SALV. Your making a greater scruple of this than of the other instances dependeth, if I mistake not, upon the birds being animated, and thereby enabled to use their strength at pleasure against the primary motion in-bred in terrene bodies: like as for example,

example, we see them whilst they are alive to fly upwards, a thing altogether impossible for them to do as they are grave bodies; whereas being dead they can only fall downwards; and therefore you hold that the reasons that are of force in all the kinds of projects above named, cannot take place in birds: Now this is very true; and because it is so; *Sagredus*, that doth not appear to be done in those projects, which we see the birds to do. For if from the top of a Tower you let fall a dead bird and a live one, the dead bird shall do the same that a stone doth, that is, it shall first follow the general motion diurnal, and then the motion of descent, as grave; but if the bird let fall, be a live, what shall hinder it, (there ever remaining in it the diurnal motion) from soaring by help of its wings to what place of the Horizon it shall please? and this new motion, as being peculiar to the bird, and not participated by us, must of necessity be visible to us; and if it be moved by help of its wings towards the West, what shall hinder it from returning with a like help of its wings unto the Tower. And, because, in the last place, the bird swending its flight towards the West was no other than a withdrawing from the diurnal motion, (which hath, suppose ten degrees of velocity) one degree only, there did thereupon remain to the bird whilst it was in its flight nine degrees of velocity, and so soon as it did alight upon the the Earth, the ten common degrees returned to it, to which, by flying towards the East it might adde one, and with those eleven overtake the Tower. And in short, if we well consider, and more narrowly examine the effects of the flight of birds, they differ from the projects shot or thrown to any part of the World in nothing, save only that the projects are moved by an external projicient, and the birds by an internal principle. And here for a final proof of the nullity of all the experiments before alledged, I conceive it now a time and place convenient to demonstrate a way how to make an exact trial of them all, Shut your self up with some friend in the grand Cabbins between the decks of some large Ship, and there procure gnats, flies, and such other small winged creatures: get also a great tub (or other vessel) full of water, and within it put certain fishes; let also a certain bottle be hung up, which drop by drop letteth forth its water into another bottle placed underneath, having a narrow neck: and, the Ship lying still, observe diligently how those small winged animals fly with like velocity towards all parts of the Cabin; how the fishes swim indifferently towards all sides; and how the distilling drops all fall into the bottle placed underneath. And casting any thing towards your friend, you need not throw it with more force one way then another, provided the distances be equal: and leaping, as the saying is, with your feet closed, you will reach

The answer to the argument taken from the flight of birds contrary to the motion of the Earth.

An experiment with which alone is shewn the nullity of all the objections produced against the motion of the Earth.

as far one way as another. Having observed all these particulars, though no man doubteth that so long as the vessel stands still, they ought to succeed in this manner; make the Ship to move with what velocity you please; for (so long as the motion is uniforme, and not fluctuating this way and that way) you shall not discern any the least alteration in all the forenamed effects; nor can you gather by any of them whether the Ship doth move or stand still. In leaping you shall reach as far upon the floor, as before; nor for that the Ship moveth shall you make a greater leap towards the poop than towards the prow; howbeit in the time that you staid in the Air, the floor under your feet shall have run the contrary way to that of your jump; and throwing any thing to your companion you shall not need to cast it with more strength that it may reach him, if he shall be towards the prow, and you towards the poop, then if you stood in a contrary situation; the drops shall all distill as before into the inferiour bottle, and not so much as one shall fall towards the poop, albeit whilst the drop is in the Air, the Ship shall have run many feet; the Fishes in their water shall not swim with more trouble towards the fore-part, than towards the hinder part of the tub; but shall with equal velocity make to the bait placed on any side of the tub; and lastly, the flies and gnats shall continue their flight indifferently towards all parts; nor shall they ever happen to be driven together towards the side of the Cabbin next the prow, as if they were wearied with following the swift course of the Ship, from which through their suspension in the Air, they had been long separated; and if burning a few graines of incense you make a little smoke, you shall see it ascend on high, and there in manner of a cloud suspend it self, and move indifferently, not inclining more to one side than another: and of this correspondence of effects the cause is for that the Ships motion is common to all the things contained in it, and to the Air also; I mean if those things be shut up in the Cabbin: but in case those things were above deck in the open Air, and not obliged to follow the course of the Ship, differences more or lesse notable would be observed in some of the fore-named effects, and there is no doubt but that the smoke would stay behind as much as the Air it self; the flies also, and the gnats being hindered by the Air would not be able to follow the motion of the Ship, if they were separated at any distance from it. But keeping neer thereto, because the Ship it self as being an unfractuous Fabrick, carrieth along with it part of its neereft Air, they would follow the said Ship without any pains or difficulty. And for the like reason we see sometimes in riding post, that the troublesome flies and *hornets do follow the horses flying sometimes to one, sometimes to another part of the body, but in the falling drops the

Tubis, horse-
the

the difference would be very small; and in the salts; and projections of grave bodies altogether imperceptible.

SAGR. Though it came not into my thoughts to make triall of these observations, when I was at Sea, yet am I confident that they will succeed in the same manner, as you have related; in confirmation of which I remember that being in my Cabbin I have asked an hundred times whether the Ship moved or stood still; and sometimes I have imagined that it moved one way, when it steered quite another way. I am therefore as hitherto satisfied and convinced of the nullity of all those experiments that have been produced in proof of the negative part. There now remains the objection founded upon that which experience shews us; namely, that a swift *Vertigo* or whirling about hath a faculty to extrude and disperse the matters adherent to the machine that turns round; whereupon many were of opinion, and *Ptolomy* amongst the rest, that if the Earth should turn round with so great velocity, the stones and creatures upon it should be tost into the Skie, and that there could not be a mortar strong enough to fasten buildings so to their foundations; but that they would likewise suffer a like extrusion.

SALV. Before I come to answer this objection, I cannot but take notice of that which I have an hundred times observed, and not without laughter, to come into the minds of most men so soon as ever they hear mention made of this motion of the Earth, which is believed by them so fixt and immoveable, that they not only never doubted of that rest, but have ever strongly believed that all other men as well as they, have held it to be created immoveable, and so to have continued through all succeeding ages: and being settled in this perswasion, they stand amazed to hear that any one should grant it motion, as if, after that he had held it to be immoveable, he had fondly thought it to commence its motion then (and not till then) when *Pythagoras* (or whoever else was the first hater of its mobility) said that it did move. Now that such a foolish conceit (I mean of thinking that those who admit the motion of the Earth, have first thought it to stand still from its creation, untill the time of *Pythagoras*, and have onely made it moveable after that *Pythagoras* esteemed it so) findeth a place in the mindes of the vulgar, and men of shallow capacities, I do not much wonder; but that such persons as *Aristotle* and *Ptolomy* should also run into this childish mistake, is to my thinking a more admirable and unpardonable folly.

SAGR. You believe then, *Salviatus*, that *Ptolomy* thought, that in his Disputation he was to maintain the stability of the Earth against such persons, as granting it to have been immoveable, untill the time of *Pythagoras*, did affirm it to have been but then made

The stupidity of some that think the Earth to have begun to move, when Pythagoras began to affirm that it did so.

Aristotle and
Ptolemy seem to
confute the mobili-
ty of the Earth a-
gainst those who
thought that it ha-
ving a long time
stood still, did be-
gin to move in the
time of Pythagoras

made moveable, when the said Pythagoras ascribed unto it motion.

SALV. We can think no other, if we do but consider the way he taketh to confute their assertion; the confutation of which consists in the demolition of buildings, and the tossing of stones, living creatures and men themselves up into the Air. And because such overthrows and extulsions cannot be made upon buildings and men, which were not before on the Earth, nor can men be placed, nor buildings erected upon the Earth, unlesse when it standeth still; hence therefore it is cleer, that *Ptolemy* argueth against those, who having granted the stability of the Earth for some time, that is, so long as living creatures, stones, and Masons were able to abide there, and to build Palaces and Cities, make it afterwards precipitately moveable to the overthrow and destruction of Edifices, and living creatures, &c. For if he had undertook to dispute against such as had ascribed that revolution to the Earth from its first creation, he would have confuted them by saying, that if the Earth had alwayes moved, there could never have been placed upon it either men or stones; much less could buildings have been erected, or Cities founded, &c.

SIMP. I do not well conceive these *Aristotelick* and *Ptolemaick* inconveniences.

SALV. *Ptolemy* either argueth against those who have esteemed the Earth alwayes moveable; or against such as have held that it stood for some time still, and hath since been set on moving. If against the first, he ought to say, that the Earth did not alwayes move, for that then there would never have been men, animals, or edifices on the Earth, its *vertigo* not permitting them to stay thereon. But in that he arguing, saith that the Earth doth not move, because that beasts, men, and houses before plac'd on the Earth would precipitate, he supposeth the Earth to have been once in such a state, as that it did admit men and beasts to stay, and build thereon; the which draweth on the consequence, that it did for some time stand still, to wit, was apt for the abode of animals and erection of buildings. Do you now conceive what I would say?

SIMP. I do, and I do not; but this little importeth to the merit of the cause; nor can a small mistake of *Ptolemy*, committed through inadvertencie be sufficient to move the Earth, when it is immoveable. But omitting cavils, let us come to the substance of the argument, which to me seems unanswerable.

SALV. And I, *Simplicius*, will drive it home, and re-inforce it, by shewing yet more sensibly, that it is true that grave bodies turn'd with velocity about a settled centre, do acquire an *impetus* of moving, and receding to a distance from that centre, even
thei

then when they are in a state of having a propension of moving naturally to the same. Tie a bottle that hath water in it, to the end of a cord, and holding the other end fast in your hand, and making the cord and your arm the semi-diameter, and the knitting of the shoulder the centre, swing the bottle very fast about, so as that it may describe the circumference of a circle, which, whether it be parallel to the Horizon, or perpendicular to it, or any way inclined, it shall in all cases follow, that the water will not fall out of the bottle: nay, he that shall swing it, shall find the cord always draw, and strive to go farther from the shoulder. And if you bore a hole in the bottom of the bottle, you shall see the water spout forth no less upwards into the skie, than laterally, and downwards to the Earth; and if instead of water, you shall put little pebble stones into the bottle, and swing it in the same manner, you shall find that they will strive in the like manner against the cord. And lastly, we see boys throw stones a great way, by swinging round a piece of a stick, at the end of which the stone is let into a slit (*which stick is called by them a sling*) all which are arguments of the truth of the conclusion, to wit, that the *vertigo* or swing conferreth upon the moveable, a motion towards the circumference, in case the motion be swift: and therefore if the Earth revolve about its own centre, the motion of the superficies, and especially towards the great circle, as being incomparably more swift than those before named, ought to extrude all things up into the air.

SIMP. The Argument seemeth to me very well proved and enforced; and I believe it would be an hard matter to answer and overthrow it.

SALV. Its solution dependeth upon certain notions no less known and believed by you, than by my self: but because they come not into your mind, therefore it is that you perceive not the answer; wherefore, without telling you it (for that you know the same already) I shall with onely assisting your memory, make you to refute this argument.

SIMP. I have often thought of your way of arguing, which hath made me almost think that you lean to that opinion of *Plato*; *Quod nostrum scire sit quoddam reminisci*; therefore I intreat you to free me from this doubt, by letting me know your judgment.

SALV. What I think of the opinion of *Plato*, you may gather from my words and actions. I have already in the precedent conferences expressly declared my self more than once; I will pursue the same style in the present case, which may hereafter serve you for an example, thereby the more easily to gather what my opinion is touching the attainment of knowledg, when a time shall offer

Our knowledg is
a kind of reminiscence according to
Plato.

offer upon some other day : but I would not have *Sagredus* offended at this digression.

SAGR. I am rather very much pleased with it, for that I remember that when I studied Logick, I could never comprehend that so much cry'd up and most potent demonstration of *Aristotle*.

SALV. Let us go on therefore; and let *Simplicius*, tell me what that motion is which the stone maketh that is held fast in the slit of the sling, when the boy swings it about to throw it a great way?

SIMP. The motion of the stone, so long as it is in the slit, is circular, that is, moveth by the arch of a circle, whose stedfast centre is the knitting of the shoulder, and its semi-diameter the arm and stick.

SALV. And when the stone leaveth the sling, what is its motion? Doth it continue to follow its former circle, or doth it go by another line?

SIMP. It will continue no longer to swing round, for then it would not go farther from the arm of the projicient, whereas we see it go a great way off.

SALV. With what motion doth it move then?

SIMP. Give me a little time to think thereof; For I have never considered it before.

SALV. Hark hither, *Sagredus*; this is the *Quoddam reminisci* in a subject well understood. You have paused a great while, *Simplicius*.

SIMP. As far as I can see, the motion received in going out of the sling, can be no other than by a right line; nay, it must necessarily be so, if we speak of the pure adventitious *impetus*. I was a little puzzled to see it make an arch, but because that arch bended all the way upwards, and no other way, I conceive that that incurvation cometh from the gravity of the stone, vvhich naturally dravveth it dovvnvwards. The impressed *impetus*, I say, vvithout respecting the natural, is by a right line.

The motion impressed by the projicient is only by a right line.

SALV. But by what right line? Because infinite, and towards every side may be produced from the slit of the sling, and from the point of the stones separation from the sling.

SIMP. It moveth by that line which goeth directly from the motion which the stone made in the sling.

SALV. The motion of the stone whilst it was in the slit, you have affirmed already to be circular; now circularity opposeth directness, there not being in the circular line any part that is direct or streight.

SIMP. I mean not that the projected motion is direct in respect of the whole circle, but in reference to that ultimate point, where the circular motion determineth. I know what I would say,

say, but do not well know how to express my self.

SALV. And I also perceive that you understand the business, but that you have not the proper terms, wherewith to express the same. Now these I can easily teach you; teach you, that is, as to the words, but not as to the truths, which are things. And that you may plainly see that you know the thing I ask you, and onely want language to express it, tell me, when you shoot a bullet out of a gun, towards what part is it, that its acquired *impetus* carrieth it?

SIMP. Its acquired *impetus* carrieth it in a right line, which continueth the rectitude of the barrel, that is, which inclineth neither to the right hand nor to the left, nor upwards nor downwards.

SALV. Which in short is asmuch as to say, it maketh no angle with the line of streight motion made by the sling.

SIMP. So I would have said.

SALV. If then the line of the projects motion be to continue without making an angle upon the circular line described by it, whilst it was with the projicient; and if from this circular motion it ought to pass to the right motion, what ought this right line to be?

SIMP. It must needs be that which toucheth the circle in the point of separation, for that all others, in my opinion, being prolonged would intersect the circumference, and by that means make some angle therewith.

SALV. You have argued very well, and shewn your self half a Geometrician. Keep in mind therefore, that your true opinion is expressed in these words, namely, That the project acquireth an *impetus* of moving by the Tangent, the arch described by the motion of the projicient, in the point of the said projects separation from the projicient.

SIMP. I understand you very well, and this is that which I would say.

SALV. Of a right line which toucheth a circle, which of its points is the nearest to the centre of that circle?

SIMP. That of the contact without doubt: for that is in the circumference of a circle, and the rest without: and the points of the circumference are all equidistant from the centre.

SALV. Therefore a moveable departing from the contact, and moving by the streight Tangent, goeth continually farther and farther from the contact, and also from the centre of the circle.

SIMP. It doth so doubtless.

SALV. Now if you have kept in mind the propositions, which you have told me, lay them together, and tell me what you gather from them.

SIMP. I think I am not so forgetful, but that I do remember them.

The project moveth by the Tangent of the circle of the motion precedent in the point of separation.

them. From the things premised I gather that the project swiftly swinged round by the projicient, in its separating from it, doth retain an *impetus* of continuing its motion by the right line, which toucheth the circle described by the motion of the projicient in the point of separation, by which motion the project goeth continually receding from the centre of the circle described by the motion of the projicient.

SALV. You know then by this time the reason why grave bodies sticking to the rim of a wheele, swiftly moved, are extruded and thrown beyond the circumference to yet a farther distance from the centre.

SIMP. I think I understand this very well; but this new knowledg rather increaseth than lesseneth my incredulity that the Earth can turn round with so great velocity, without extruding up into the sky, stones, animals, &c.

SALV. In the same manner that you have understood all this, you shall, nay you do understand the rest: and with recollecting your self, you may remember the same without the help of others: but that we may lose no time, I will help your memory therein. You do already know of your self, that the circular motion of the projicient impresseth on the project an *impetus* of moving (when they come to separate) by the right Tangent, the circle of the motion in the point of separation, and continuing along by the same the motion ever goeth receding farther and farther from the projicient: and you have said, that the project would continue to move along by that right line, if there were not by its proper weight an inclination of descent added unto it; from which the incurvation of the line of motion is derived. It seems moreover that you knew of your self, that this incurvation always bended towards the centre of the Earth, for thither do all grave bodies tend. Now I proceed a little farther, and ask you, whether the moveable after its separation, in continuing the right motion goeth always equally receding from the centre, or if you will, from the circumference of that circle, of which the precedent motion was a part; which is as much as to say, Whether a moveable, that forsaking the point of a Tangent, and moving along by the said Tangent, doth equally recede from the point of contact, and from the circumference of the circle?

SIMP. No, Sir: for the Tangent near to the point of contact, recedeth very little from the circumference, wherewith it keepeth a very narrow angle, but in its going farther and farther off, the distance always encreaseth with a greater proportion; so that in a circle that should have v. g. ten yards of diameter, a point of the Tangent that was distant from the contact but two palms, would be three or four times as far distant from the circumference of

of the circle, as a point that was distant from the contact one palm; and the point that was distant half a palm, I likewise believe would scarce recede the fourth part of the distance of the second: so that within an inch or two of the contact, the separation of the Tangent from the circumference is scarce discernable.

SALV. So that the recession of the project from the circumference of the precedent circular motion is very small in the beginning?

SIMP. Almost insensible.

SALV. Now tell me a little; the project, which from the motion of the projectant receiveth an *impetus* of moving along the Tangent in a right line; and that would keep unto the same; did not its own weight depress it downwards, how long is it after the separation, ere it begin to decline downwards.

SIMP. I believe that it beginneth presently; for it not having any thing to uphold it, its proper gravity cannot but operate.

SALV. So that, if that same stone, which being extruded from that wheel turn'd about very fast, had as great a natural propension of moving towards the centre of the said wheel, as it hath to move towards the centre of the Earth, it would be an easie matter for it to return unto the wheel, or rather not to depart from it; in regard that upon the beginning of the separation, the recession being so small; by reason of the infinite acuteness of the angle of contact, every very little of inclination that draweth it back towards the centre of the wheel, would be sufficient to retain it upon the rim or circumference.

SIMP. I question not, but that if one suppose that which neither is, nor can be, to wit, that the inclination of those grave bodies was to go towards the centre of the wheel, they would never come to be extruded or shaken off.

SALV. But I neither do, nor need to suppose that which is not; for I will not deny but that the stones are extruded. Yet I speak this by way of supposition, to the end that you might grant me the rest. Now fancy to your self, that the Earth is that great wheel, which moved with so great velocity is to extrude the stones. You could tell me very well even now, that the motion of projection ought to be by that right line which toucheth the Earth in the point of separation: and this Tangent, how doth it notably recede from the superficies of the Terrestrial Globe?

SIMP. I believe, that in a thousand yards, it will not recede from the Earth an inch.

SALV. And did you not say, that the project being drawn by its own weight, declineth from the Tangent towards the centre of the Earth?

SIMP.

A grave project, as soon as it is separated from the projectant beginneth to decline.

SIMP. I said so, and also confesse the rest: and do now plainly understand that the stone will not separate from the Earth, for that its recession in the beginning would be such, and so small, that it is a thousand times exceeded by the inclination which the stone hath to move towards the centre of the Earth, which centre in this case is also the centre of the wheel. And indeed it must be confessed that the stones, the living creatures, and the other grave bodies cannot be extruded; but here again the lighter things beget in me a new doubt, they having but a very weak propension of descent towards the centre; so that there being wanting in them that faculty of withdrawing from the superficies, I see not, but that they may be extruded; and you know the rule, that *ad destruendum sufficit unum*.

SALV. We will also give you satisfaction in this. Tell me therefore in the first place, what you understand by light matters, that is, whether you thereby mean things really so light, as that they go upvvards, or else not absolutely light, but of so small gravity, that though they descend downwards, it is but very slowly; for if you mean the absolutely light, I will be readier than your self to admit their extrusion.

SIMP. I speak of the other sort, such as are feathers, wool, cotton, and the like; to lift up which every small force sufficeth: yet nevertheless we see they rest on the Earth very quietly.

SALV. This pen, as it hath a natural propension to descend towards the superficies of the Earth, though it be very small, yet I must tell you that it sufficeth to keep it from mounting upwards: and this again is not unknown to you your self; therefore tell me if the pen were extruded by the *Vertigo* of the Earth, by what line would it move?

SIMP. By the rangent in the point of separation.

SALV. And when it should be to return, and re-unite it self to the Earth, by what line would it then move?

SIMP. By that which goeth from it to the centre of the Earth.

SALV. So then here falls under our consideration two motions; one the motion of projection, which beginneth from the point of contact, and proceedeth along the tangent; and the other the motion of inclination downwards, which beginneth from the project it self, and goeth by the secant towards the centre; and if you desire that the projection follow, it is necessary that the *impetus* by the tangent overcome the inclination by the secant: is it not so?

SIMP. So it seemeth to me.

SALV. But what is it that you think necessary in the motion of the projicient, to make that it may prevail over that inclination,

tion, from which ensueth the separation and elongation of the pen from the Earth?

SIMP. I cannot tell.

SALV. How, do you not know that? The moveable is here the same, that is, the same pen; now how can the same moveable superate and exceed it self in motion?

SIMP. I do not see how it can overcome or yield to it self in motion, unlesse by moving one while faster, and another while slower.

SALV. You see then, that you do know it. If therefore the projection of the pen ought to follow, and its motion by the tangent be to overcome its motion by the secant, what is it requisite that their velocities should be?

SIMP. It is requisite that the motion by the tangent be greater than that other by the secant. But wretch that I am! Is it not only many thousand times greater than the descending motion of the pen, but than that of the stone? And yet like a simple fellow I had suffered my self to be perswaded, that stones could not be extruded by the revolution of the Earth. I do therefore revoke my former sentence, and say, that if the Earth should move, stones, Elephants, Towers, and whole Cities would of necessity be tost up into the Air; and because that that doth not evene, I conclude that the Earth doth not move.

SALV. Softly *Simplicius*, you go on so fast, that I begin to be more afraid for you, than for the pen. Rest a little, and observe what I am going to speake. If for the reteining of the stone or pen annexed to the Earths surface it were necessary that its motion of descent were greater, or as much as the motion made by the tangent; you would have had reason to say, that it ought of necessity to move as fast, or faster by the secant downwards, than by the tangent Eastwards. But did not you tell me even now, that a thousand yards of distance by the tangent from the contact, do remove hardly an inch from the circumference? It is not sufficient therefore that the motion by the tangent, which is the same with that of the diurnall *Vertigo*, (or hasty revolution) be simply more swift than the motion by the secant, which is the same with that of the pen in descending; but it is requisite that the same be so much more swift as that the time which sufficeth for the pen to move w.g. a thousand yards by the tangent, be insufficient for it to move one sole inch by the secant. The which I tell you shall never be, though you should make that motion never so swift, and this never so slow.

SIMP. And why might not that by the tangent be so swift, as not to give the pen time to return to the surface of the Earth?

SALV. Try whether you can state the case in proper termes, and

and I will give you an answer. Tell me therefore, how much do you think sufficeth to make that motion swifter than this?

SIMP. I will say for example, that if that motion by the tangent were a million of times swifter than this by the secant, the pen, yea, and the stone also would come to be extruded.

SALV. You say so, and say that which is false; onely for want, not of Logick, Physicks, or Metaphysicks, but of Geometry; for if you did but understand its first elements, you would know, that from the centre of a circle a right line may be drawn to meet the tangent, which intersecteth it in such a manner, that the part of the tangent between the contact and the secant, may be one, two, or three millions of times greater than that part of the secant which lieth between the tangent and the circumference, and that the neerer and neerer the secant shall be to the contact, this proportion shall grow greater and greater *in infinitum*; so that it need not be feared, though the *vertigo* be swift, and the motion downwards slow, that the pen or other lighter matter can begin to rise upwards, for that the inclination downwards always exceedeth the velocity of the projection.

SAGR. I do not perfectly apprehend this businesse.

A geometrical demonstration to prove the impossibility of extrusion by means of the terrestrial vertigo.

SALV. I will give you a most universal yet very easie demonstration thereof. Let a proportion be given between BA [in Fig. 3.] and C: And let BA be greater than C at pleasure. And let there be described a circle, whose centre is D. From which it is required to draw a secant, in such manner, that the tangent may be in proportion to the said secant, as BA to C. Let AI be supposed a third proportional to BA and C. And as BI is to IA, so let the diameter FE be to EG; and from the point G, let there be drawn the tangent GH. I say that all this is done as was required; and as BA is to C, so is HG to GE. And in regard that as BI is to IA, so is FE to EG; therefore by composition, as BA is to AI; so shall FG be to GE. And because C is the middle proportion between BA and AI; and GH is a middle term between FG and GE; therefore, as BA is to C, so shall FG be to GH; that is HG to GE, which was to be demonstrated.

SAGR. I apprehend this demonstration; yet neverthelesse, I am not left wholly without hæitation; for I find certain confused scruples role to and again in my mind, which like thick and dark clouds, permit me not to discern the cleernesse and necessity of the conclusion with that perspicuity, which is usual in Mathematical Demonstrations. And that which I stick at is this. It is true that the spaces between the tangent and the circumference do gradually diminish *in infinitum* towards the contact; but it is also true on the contrary, that the propension of the moveable to de-

descending groweth less & less in it, the nearer it is to the first term of its descent; that is, to the state of rest; as is manifest from that which you declare unto us, demonstrating that the descending grave body departing from rest, ought to passe thorow all the degrees of tardity comprehended between the said rest, & any assigned degree of velocity, the which grow less and less *in infinitum*. To which may be added, that the said velocity and propension to motion, doth for another reason diminish to infinity; and it is because the gravity of the said moveable may infinitely diminish. So that the causes which diminish the propension of ascending, and consequently favour the projection, are two; that is, the levity of the moveable, and its vicinity to the state of rest; both which are augmentable *in infinitum*. and these two on the contrary being to contract but with one sole cause of making the projection, I cannot conceive how it alone, although it also do admit of infinite augmentation, should be able to remain invincible against the union & confederacy of the others, which are two, and are in like manner capable of infinite augmentation.

SALV. This is a doubt worthy of *Sagredus*; and to explain it so as that we may more cleerly apprehend it, for that you say that you your self have but a confused *Idea* of it, we will distinguish of the same by reducing it into figure; which may also perhaps afford us some ease in resolving the same. Let us therefore [*in Fig. 4.*] draw a perpendicular line towards the centre, and let it be AC, and to it at right angles let there be drawn the Horizontal line AB, upon which the motion of the projection ought to be made; now the project would continue to move along the same with an even motion, if so be its gravity did not incline it downwards. Let us suppose from the point A a right line to be drawn, that may make any angle at pleasure with the line AB; which let be AE, and upon AB let us mark some equal spaces AF, FH, HK, and from them let us let fall the perpendiculars FG, HI, KL, as far as AE. And because, as already hath been said, the descending grave body departing from rest, goeth from time to time acquiring a greater degree of velocity, according as the said time doth successively encrease; we may conceive the spaces AF, FH, HK, to represent unto us equal times; and the perpendiculars FG, HI, KL, degrees of velocity acquired in the said times; so that the degree of velocity acquired in the whole time AK, is as the line KL, in respect to the degree HI, acquired in the time AH, and the degree FG in the time AF; the which degrees KL, HI, FG, are (as is manifest) the same in proportion, as the times KA, HA, FA, and if other perpendiculars were drawn from the points marked at pleasure in the line EA, one might successively find degrees lesse and lesse *in infinitum*, proceeding towards the point A, representing the first instant of time, and the first state of rest. And this retreat towards A, representeth the first propension to the

Z

mo-

motion of descent, diminished *in infinitum* by the approach of the moveable to the first state of rest, which approximation is augmentable *in infinitum*. Now let us find the other diminution of velocity, which likewise may proceed to infinity, by the diminution of the gravity of the moveable; and this shall be represented by drawing other lines from the point A, which contain angles lesse than the angle B A E, which would be this line A D, the which intersecting the parallels K L, H I, F G, in the points M, N, and O, represent unto us the degrees F O, H N, K M, acquired in the times A F, A H, A K, lesse than the other degrees F G, H I, K L, acquired in the same times; but these latter by a moveable more ponderous, and those other by a moveable more light. And it is manifest, that by the retreat of the line E A towards A B, contracting the angle E A B (the which may be done *in infinitum*, like as the gravity may *in infinitum* be diminished) the velocity of the cadent moveable may in like manner be diminished *in infinitum*, and so consequently the cause that impeded the projection; and therefore my thinks that the union of these two reasons against the projection, diminished to infinity, cannot be any impediment to the said projection. And couching the whole argument in its shortest terms, we will say, that by contracting the angle E A B, the degrees of velocity L K, I H, G F, are diminished; and moreover by the retreat of the parallels K L, H I, F G, towards the angle A, the same degrees are again diminished; and both these diminutions extend to infinity: Therefore the velocity of the motion of descent may very well diminish so much, (it admitting of a twofold diminution *in infinitum*) as that it may not suffice to restore the moveable to the circumference of the wheel, and thereupon may occasion the projection to be hindered and wholly obviated.

Again on the contrary, to impede the projection, it is necessary that the spaces by which the project is to descend for the reuniting it self to the Wheel, be made so short and close together, that though the descent of the moveable be retarded, yet more, diminished *in infinitum*, yet it sufficeth to reconduct it thither: and therefore it would be requisite, that you find out a diminution of the said spaces, not only produced to infinity, but to such an infinity, as that it may superate the double infinity that is made in the diminution of the velocity of the descending moveable. But how can a magnitude be diminished more than another, which hath a twofold diminution *in infinitum*? Now let *Simplicius* observe how hard it is to philosophate well in nature, without *Geometry*. The degrees of velocity diminished *in infinitum*, as well by the diminution of the gravity of the moveable, as by the approximation to the first term of the motion, that is, to the state of

of rest, are alwayes determinate, and answer in proportion to the parallels comprehended between two right lines that concur in an angle, like to the angle BAE , or BAD , or any other infinitely more acute, alwayes provided it be rectilineall. But the diminution of the spaces thorow which the moveable is to be conducted along the circumference of the wheel, is proportionate to another kind of diminution, comprehended between lines that contain an angle infinitely more narrow and acute, than any rectilineal angle, how acute soever, which is that in our present case. Let any point be taken in the perpendicular AC , and making it the centre, describe at the distance CA , an arch AMP , the which shall intersect the parallels that determine the degrees of velocity, though they be very minute, and comprehended within a most acute rectilineal angle; of which parallels the parts that lie between the arch and the tangent AB , are the quantities of the spaces, and of the returns upon the wheel, alwayes lesser (and with greater proportion lesser, by how much neerer they approach to the contact) than the said parallels of which they are parts. The parallels comprehended between the right lines in retiring towards the angle diminish alwayes at the same rate, as *v.g.* AH being divided in two equal parts in F , the parallel HI shall be double to FG , and sub-dividing FA , in two equal parts, the parallel produced from the point of the division shall be the half of FG ; and continuing the sub-division *in infinitum*, the subsequent parallels shall be alwayes half of the next preceding; but it doth not so fall out in the lines intercepted between the tangent and the circumference of the circle: For if the same sub-division be made in FA ; and supposing for example, that the parallel which cometh from the point H , were double unto that which cometh from F , this shall be more then double to the next following, and continually the neerer we come towards the contact A , we shall find the precedent lines contain the next following three, four, ten, an hundred, a thousand, an hundred thousand, an hundred millions of times, and more *in infinitum*. The brevity therefore of such lines is so reduced, that it far exceeds what is requisite to make the project, though never so light, return, nay more, continue unremoveable upon the circumference.

SAGG. I very well comprehend the whole discourse, and upon what it layeth all its stress, yet nevertheless methinks that he that would take pains to pursue it, might yet start some further questions; by saying, that of those two causes which render the descent of the moveable slower and slower *in infinitum*, it is manifest, that that which dependeth on the vicinity to the first term of the descent, increaseth alwayes in the same proportion, like as the parallels alwayes retain the same proportion to each other, &c.

Z 2

but

but that the diminution of the same velocity, dependent on the diminution of the gravity of the moveable (which was the second cause) doth also observe the same proportion, doth not so plainly appear. And vvhho shall assure us that it doth not proceed according to the proportion of the lines intercepted between the secant, and the circumference; or vvwhether vvith a greater proportion?

SALV. I have assumed for a truth, that the velocities of moveables descending naturally, vvill follow the proportion of their gravities, with the favour of *Simplicius*, and of *Aristotle*, who doth in many places affirm the same, as a proposition manifest: You, in favour of my adversary, bring the same into question, and say that its possible that the velocity increaseth with greater proportion, yea and greater *in infinitum* than that of the gravity; so that all that hath been said falleth to the ground: For maintaining whereof, I say, that the proportion of the velocities is much lesse than that of the gravities; and thereby I do not onely support but confirme the premises. And for proof of this I appeal unto experience, which will shew us, that a grave body, howbeit thirty or forty times bigger then another; as for example, a ball of lead, and another of sugar, will not move much more than twice as fast. Now if the projection would not be made, albeit the velocity of the cadent body should diminish according to the proportion of the gravity, much lesse would it be made so long as the velocity is but little diminished, by abating much from the gravity. But yet supposing that the velocity diminisheth with a proportion much greater than that wherewith the gravity decreaseth, nay though it were the self-same wherewith those parallels contained between the tangent and circumference do decrease, yet cannot I see any necessity why I should grant the projection of matters of never so great levity; yea I farther averre, that there could no such projection follow, meaning alwayes of matters not properly and absolutely light, that is, void of all gravity, and that of their own natures move upwards, but that descend very slowly, and have very small gravity. And that which moveth me so to think is, that the diminution of gravity, made according to the proportion of the parallels between the tangent and the circumference, hath for its ultimate and highest term the nullity of weight, as those parallels have for their last term of their diminution the contact it self, which is an indivisible point: Now gravity never diminisheth so far as to its last term, for then the moveable would cease to be grave; but yet the space of the reversion of the project to the circumference is reduced to the ultimate minuity, which is when the moveable resteth upon the circumference in the very point of contact; so as that to return thither it hath no need of space: and therefore let the propension to the motion of descent be never

ver so small, yet is it alwayes more than sufficient to reconduct the moveable to the circumference, from which it is distant but its least space, that is, nothing at all.

SAGR. Your discourse, I must confesse, is very accurate; and yet no less concluding than it is ingenuous; and it must be granted that to go about to handle natural questions, without *Geometry*, is to attempt an impossibility.

SALV. But *Simplicius* will not say so; and yet I do not think that he is one of those *Peripateticks* that dissuade their Disciples from studying the *Mathematicks*, as Sciences that vitiate the reason, and render it lesse apt for contemplation.

SIMP. I would not do so much wrong to *Plato*, but yet I may truly say with *Aristotle*, that he too much lost himself in, and too much doted upon that his *Geometry*: for that in conclusion these Mathematical subtilties *Salvianus* are true in abstract, but applied to sensible and Physicall matter, they hold not good. For the Mathematicians will very well demonstrate for example, that *Sphæra tangit planum in puncto*; a position like to that in dispute, but when one cometh to the matter, things succeed quite another way. And so I may say of these angles of contact; and these proportions; which all evaporate into Air, when they are applied to things material and sensible.

SALV. You do not think then, that the tangent toucheth the superficies of the terrestrial Globe in one point only?

SIMP. No, not in one sole point; but I believe that a right line goeth many tens and hundreds of yards touching the surface not onely of the Earth, but of the water, before it separate from the same.

SALV. But if I grant you this, do not you perceive that it maketh so much the more against your cause? For if it be supposed that the tangent was separated from the terrestrial superficies, yet it hath been however demonstrated that by reason of the great acuity of the angle of contingence (if happily it may be call'd an angle) the project would not separate from the same; how much lesse cause of separation would it have, if that angle should be wholly closed, and the superficies and the tangent become all one? Perceive you not that the Projection would do the same thing upon the surface of the Earth, which is as much as to say, it would do just nothing at all? You see then the power of truth, which while you strive to oppose it, your own assaults themselves uphold and defend it. But in regard that you have retracted this error, I would be loth to leave you in that other which you hold, namely, that a material Sphere doth not touch a plain in one sole point: and I could wish some few hours conversation with some persons conversant in *Geometry*, might make you a little more intelligent amongst

The truth
sometimes gains
strength by con-
tradiction.

amongst those who know nothing thereof. Now to shew you how great their error is who say, that a Sphere *v.g.* of brass, doth not touch a plain *v.g.* of steel in one sole point, Tell me what conceit you would entertain of one that should constantly aver, that the Sphere is not truly a Sphere.

SIMP. I would esteem him wholly devoid of reason.

The Sphere although material, toucheth the material plane but in one point onely.

SALV. He is in the same case who saith that the material Sphere doth not touch a plain, also material, in one onely point; for to say this is the same, as to affirm that the Sphere is not a Sphere. And that this is true, tell me in what it is that you constitute the Sphere to consist, that is, what it is that maketh the Sphere differ from all other solid bodies.

The definition of the sphere.

SIMP. I believe that the essence of a Sphere consisteth in having all the right lines produced from its centre to the circumference, equal.

SALV. So that, if those lines should not be equal, there same solidity would be no longer a sphere?

SIMP. True.

SALV. Go to; tell me whether you believe that amongst the many lines that may be drawn between two points, that may be more than one right line onely.

SIMP. There can be but one.

SALV. But yet you understand that this onely right line shall again of necessity be the shortest of them all?

SIMP. I know it, and also have a demonstration thereof, produced by a great *Peripatetick* Philosopher, and as I take it, if my memory do not deceive me, he alledgeth it by way of reprehending *Archimedes*, that supposeth it as known, when it may be demonstrated.

SALV. This must needs be a great Mathematician, that knew how to demonstrate that which *Archimedes* neither did, nor could demonstrate. And if you remember his demonstration, I would gladly hear it: for I remember very well, that *Archimedes* in his Books, *de Sphæra & Cyandro*, placeth this Proposition amongst the *Postulata*; and I verily believe that he thought it demonstrated.

SIMP. I think I shall remember it, for it is very easie and short.

SALV. The disgrace of *Archimedes*, and the honour of this Philosopher shall be so much the greater.

The demonstration of a Peripatetick, to prove the right line to be the shortest of all lines.

SIMP. I will describe the Figure of it. Between the points A and B, [in Fig. 5.] draw the right line A B, and the curve line A C B, of which we will prove the right to be the shorter: and the proof is this; take a point in the curve-line, which let be C, and draw two other lines, A C and C B, which two lines together, are longer than the sole line A B, for so demonstrateth *Euclid*.

But

But the curve-line ACB , is greater than the two right-lines AC and CB ; therefore, *a fortiori*, the curve-line ACB , is much greater than the right line AB , which was to be demonstrated.

SALV. I do not think that if one should ransack all the Paralogisms of the world, there could be found one more commodious than this, to give an example of the most solemn fallacy of all fallacies, namely, than that which proveth *ignotum per ignotius*.

SIMP. How so?

SALV. Do you ask me how so? The unknown conclusion which you desire to prove, is it not, that the curved line ACB , is longer than the right line AB ; the middle term which is taken for known, is that the curve-line ACB , is greater than the two lines AC and CB , the which are known to be greater than AB . And if it be unknown whether the curve-line be greater than the single right-line AB , shall it not be much more unknown whether it be greater than the two right lines AC & CB , which are known to be greater than the sole line AB , & yet you assume it as known?

SIMP. I do, not yet very well perceive wherein lyeth the fallacy.

SALV. As the two right lines are greater than AB , (as may be known by *Euclid*) and in as much as the curve line is longer than the two right lines AC and CB , shall it not not be much greater than the sole right line AB ?

SIMP. It shall so.

SALV. That the curve-line ACB , is greater than the right line AB , is the conclusion more known than the middle term, which is, that the same curve-line is greater than the two right lines AC and CB . Now when the middle term is less known than the conclusion, it is called a proving *ignotum per ignotius*. But to return to our purpose, it is sufficient that you know the right line to be the shortest of all the lines that can be drawn between two points. And as to the principal conclusion, you say, that the material sphere doth not touch the sphere in one sole point. What then is its contact?

SIMP. It shall be a part of its superficies.

SALV. And the contact likewise of another sphere equal to the first, shall be also a like particle of its superficies?

SIMP. There is no reason vvhy it should be othervvise.

SALV. Then the two spheres vvhich touch each other, shall touch vvith the vvwo same particles of a superficies, for each of them agreeing to one and the same plane, they must of necessity agree in like manner to each other. Imagine now that the two spheres [in Fig. 6.] whose centres are A and B , do touch one another: and let their centres be conjoynd by the right line AB , which passeth through the contact. It passeth thorow the point C , and another

The Paralogism of the same Peripatetick, which proveth ignotum per ignotius.

A demonstration that the sphere toucheth the plane but in one point.

another point in the contact being taken as D, conjoyn the two right lines A D and B D, so as that they make the triangle A D B; of which the two sides A D and D B shall be equal to the other one A C B, both those and this containing two semidiameters, which by the definition of the sphere are all equal: and thus the right line A B, drawn between the two centres A and B, shall not be the shortest of all, the two lines A D and D B being equal to it: which by your own concession is absurd.

SIMP. This demonstration holdeth in the abstracted, but not in the material spheres.

SALV. Instance then wherein the fallacy of my argument consisteth, if as you say it is not concluding in the material spheres, but holdeth good in the immaterial and abstracted.

Why the sphere in abstract, toucheth the plane onely in one point, and not the material in concrete.

SIMP. The material spheres are subject to many accidents, which the immaterial are free from. And because it cannot be, that a sphere of metal passing along a plane, its own weight should not so depress it, as that the plain should yield somewhat, or that the sphere it self should not in the contact admit of some impression. Moreover, it is very hard for that plane to be perfect, if for nothing else, yet at least for that its matter is porous: and perhaps it will be no less difficult to find a sphere so perfect, as that it hath all the lines from the centre to the superficies, exactly equal.

SALV. I very readily grant you all this that you have said; but it is very much beside our purpose: for whilst you go about to shew me that a material sphere toucheth not a material plane in one point alone, you make use of a sphere that is not a sphere, and of a plane that is not a plane; for that, according to what you say, either these things cannot be found in the world, or if they may be found, they are spoiled in applying them to work the effect. It had been therefore a less evil, for you to have granted the conclusion, but conditionally, to wit, that if there could be made of matter a sphere and a plane that were and could continue perfect, they would touch in one sole point, and then to have denied that any such could be made.

SIMP. I believe that the proposition of Philosophers is to be understood in this sense; for it is not to be doubted, but that the imperfection of the matter; maketh the matters taken in concrete, to disagree with those taken in abstract.

SALV. What, do they not agree? Why, that which you your self say at this instant, proveth that they punctually agree.

SIMP. How can that be?

SALV. Do you not say, that through the imperfection of the matter, that body which ought to be perfectly spherical, and that plane which ought to be perfectly level, do not prove to be the same

same in concrete, as they are imagined to be in abstract?

SIMP. This I do affirm.

SALV. Then when ever in concrete you do apply a material Sphere to a material plane, you apply an imperfect Sphere to an imperfect plane, & these you say do not touch only in one point. But I must tell you, that even in abstract an immaterial Sphere, that is, not a perfect Sphere, may touch an immaterial plane, that is, not a perfect plane, not in one point, but with part of its superficies, so that hitherto that which falleth out in concrete, doth in like manner hold true in abstract. And it would be a new thing that the computations and rates made in abstract numbers, should not afterwards answer to the Coines of Gold and Silver, and to the merchandizes in concrete. But do you know *Simplicius*, how this cometh to passe? Like as to make that the computations agree with the Sugars, the Silks, the Wools, it is necessary that the accomptant reckon his tares of chests, bags, and such other things: So when the *Geometrical Philosopher* would observe in concrete the effects demonstrated in abstract, he must defalke the impediments of the matter, and if he know how to do that, I do assure you, the things shall jump no lesse exactly, than *Arithmetical* computations. The errors therefore lyeth neither in abstract, nor in concrete, nor in *Geometry*, nor in *Physicks*, but in the Calculator, that knoweth not how to adjust his accompts. Therefore if you had a perfect Sphere and plane, though they were material, you need not doubt but that they would touch onely in one point. And if such a Sphere was and is impossible to be procured, it was much besides the purpose to say, *Quod Sphæra ænea non tangit in puncto*. Furthermore, if I grant you *Simplicius*, that in matter a figure cannot be procured that is perfectly spherical, or perfectly level: Do you think there may be had two materiall bodies, whose superficies in some part, and in some sort are incurvated as irregularly as can be desired?

SIMP. Of these I believe that there is no want.

SALV. If such there be, then they also will touch in one sole point; for this contact in but one point alone is not the sole and peculiar priviledge of the perfect Sphere and perfect plane. Nay, he that should prosecute this point with more subtil contemplations would finde that it is much harder to procure two bodies that touch with part of their superficies, than with one point onely. For if two superficies be required to combine well together, it is necessary either, that they be both exactly plane, or that if one be convex, the other be concave; but in such a manner concave, that the concavity do exactly answer to the convexity of the other: the which conditions are much harder to be found, in regard of their too narrow determination, than those others, which in their casuall latitude are infinite.

A a

SIMP.

Things are exactly the same in abstract as in concrete.

Contact in a single point is not peculiar to the perfect Spheres onely, but belongeth to all curved figures.

It is more difficult to find Figures that touch with a part of their surface, than in one sole point.

SIMP. You believe then, that two stones, or two pieces of Iron taken at chance, and put together, do for the most part touch in one sole point?

SALV. In casual encounters, I do not think they do; as well because for the most part there will be some small yielding filth upon them, as because that no diligence is used in applying them without striking one another; and every small matter sufficeth to make the one superficies yield somewhat to the other; so that they interchangeably, at least in some small particle, receive figure from the impression of each other. But in case their superficies were very terse and polite, and that they were both laid upon a table, that so one might not presse upon the other, and gently put towards one another, I question not, but that they might be brought to the simple contact in one onely point.

SAGR. It is requisite, with your permission, that I propound a certain scruple of mine, which came into my minde, whilst I heard proposed by *Simplicius*, the impossibility of finding a materiall and solid body, that is, perfectly of a Spherical figure, and whilst I saw *Salviatus* in a certain manner, not gain saying, to give his consent thereto; therefore I would know, whether there would be the same difficulty in forming a solid of some other figure, that is, to expresse my self better, whether there is more difficulty in reducing a piece of Marble into the figure of a perfect Sphere, than into a perfect Pyramid, or into a perfect Horse, or into a perfect Grass-hopper?

SALV. To this I will make you the first answer: and in the first place, I will acquit my self of the assent which you think I gave to *Simplicius*, which was only for a time; for I had it also in my thoughts, before I intended to enter upon any other matter, to speak that, which, it may be, is the same, or very like to that which you are about to say; And answering to your first question, I say, that if any figure can be given to a Solid, the Spherical is the easiest of all others, as it is likewise the most simple, and holdeth the same place amongst solid figures, as the Circle holdeth amongst the superficial. The description of which Circle, as being more easie than all the rest, hath alone been judged by *Mathematicians* worthy to be put amongst the *postulata* belonging to the description of all other figures. And the formation of the Sphere is so very easie, that if in a plain plate of hard metal you take an empty or hollow circle, within which any Solid goeth casually revolving that was before but grossly rounded, it shall, without any other artifice be reduced to a Spherical figure, as perfect as is possible for it to be; provided, that that same Solid be not lesse than the Sphere that would passe thorow that Circle. And that which is yet more worthy of our consideration is, that within the self-same incavity

The Sphericall Figure is easier to be made than any other.

The circular Figure only is placed amongst the postulata of Mathematicians.

* Demands or Petitions.

DIALOGUE. II.

incavity one may form Spheres of several magnitudes. But what is required to the making of an Horse, or (as you say) of a Grass-hopper, I leave to you to judge, who know that there are but few statuaries in the world able to undertake such a piece of work. And I think that herein *Simplicius* will not dissent from me.

SIMP. I know not whether I do at all dissent from you; my opinion is this, that none of the afore-named figures can be perfectly obtained; but for the approaching as neer as is possible to the most perfect degree, I believe that it is incomparably more easie to reduce the Solid into a Spherical figure, than into the shape of an Horse, or Grass-hopper?

SAGR. And this greater difficulty, wherein think you doth it depend?

SIMP. Like as the great facility in forming the Sphere ariseth from its absolute simplicity and uniformity so the great irregularity rendereth the construction of all other figures difficult.

SAGR. Therefore the irregularity being the cause of the difficulty, than the figure of a stone broken with an hammer by chance, shall be one of the figures that are difficult to be introduced, it being perhaps more irregular than that of the horse?

SIMP. So it should be.

SAGR. But tell me; that figure what ever it is which the stone hath, hath it the same in perfection, or no?

SIMP. What it hath, it hath so perfectly, that nothing can be more exact.

SAGR. Then, if of figures that are irregular, and consequently hard to be procured, there are yet infinite which are most perfectly obtained, with what reason can it be said, that the most simple, and consequently the most easie of all, is impossible to be procured?

SALV. Gentlemen, with your favour, I may say that we have fallied out into a dispute not much more worth than the wool of a goat; and whereas our argumentations should continually be conversant about serious and weighty points, we consume our time in frivolous and impertinent wranglings. Let us call to minde, I pray you, that the search of the worlds constitution, is one of the greatest and noblest Problems that are in nature; and so much the greater, inasmuch as it is directed to the resolving of that other; to wit, of the cause of the Seas ebbing and flowing, enquired into by all the famous men, that have hitherto been in the world, and possibly found out by none of them. Therefore if we have nothing more remaining for the full confutation of the argument taken from the Earths *vertigo*, which was the last, alledged to prove its immobility upon its own centre, let us passe to the examination of those things that are alledged for, and against the Annual Motion.

A a 2

SAGR.

*Irregular forms
difficult to be introduced.*

*The constitution
of the Universe is
one of the most noble
Problems.*

SAGR. I would not have you, *Salviatus*, measure our wits by the scale of yours : you, who use to be continually busied about the sublimest contemplations, esteem those notions frivolous and below you, which we think matters worthy of our profoundest thoughts : yet sometimes for our satisfaction do not disdain to stoop so low as to give way a little to our curiosity. As to the refutation of the last argument, taken from the extrusions of the diurnal *vertigo*, far less than what hath been said, would have given me satisfaction : and yet the things superfluously spoken, seemed to me so ingenious, that they have been so far from wearying my fancy, as that they have, by reason of their novelty, entertained me all along with so great delight, that I know not how to desire greater : Therefore, if you have any other speculation to add, produce it, for I, as to my own particular, shall gladly hearken to it.

SALV. I have always taken great delight in those things which I have had the fortune to discover, and next to that, which is my chief content, I find great pleasure in imparting them to some friends, that apprehendeth and seemeth to like them : Now, in regard you are one of these, slackening a little the reins of my ambition, which is much pleased when I shew my self more perspicacious, than some other that hath the reputation of a sharp sight, I will for a full and true measure of the past dispute, produce another fallacy of the Sectators of *Ptolomey* and *Aristotle*, which I take from the argument alledged.

SAGR. See how greedily I wait to hear it.

SALV. We have hitherto over-passed, and granted to *Ptolomey*, as an effect indubitable, that the extrusion of the stone proceeding from the velocity of the wheel turn'd round upon its centre, the cause of the said extrusion encreaseth in proportion, as the velocity of the *vertigo* (or whirling) is augmented : from whence it was inferred, that the velocity of the Earth's *vertigo* being very much greater than that of any machin whatsoever, that we can make to turn round artificially ; the extrusion of stones, of animals, &c. would consequently be far more violent. Now, I observe that there is a great fallacy in this discourse, in that we do compare these velocities indifferently and absolutely to one another. It's true, that if I compare the velocities of the same wheel, or of two wheels equal to each other, that which shall be more swiftly turn'd round, shall extrude the stone with greater violence, and the velocity encreasing, the cause of the projection shall likewise encrease : but when the velocity is augmented, not by encreasing the velocity in the same wheel, which would be by causing it to make a greater number of revolutions in equal times ; but by encreasing the diameter, and making the wheel greater, so that the conversion taking up the same time in the lesser wheel,

as in the greater, the velocity is greater onely in the bigger wheel, for that its circumference is bigger; there is no man that thinketh that the cause of the extrusion in the great wheel will encrease according to the proportion of the velocity of its circumference, to the velocity of the circumference of the other lesser wheel; for that this is most false, as by a most expeditious experiment I shall thus grossly declare: We may sling a stone with a stick of a yard long, farther than we can do with a stick six yards long; though the motion of the end of the long stick, that is of the stone placed in the slit thereof, were more than double as swift as the motion of the end of the other shorter stick, as it would be if the velocities were such that the lesser stick should turn thrice round in the time whilst the greater is making one onely conversion.

The cause of the projection increaseth not according to the proportion of the velocity, increased by making the wheel bigger.

SAGR. This which you tell me, *Salviatus*, must, I see, needs succeed in this very manner; but I do not so readily apprehend the cause why equal velocities should not operate equally in extruding projects, but that of the lesser wheel much more than the other of the greater wheel; therefore I intreat you to tell me how this cometh to pass?

SIMP. Herein, *Sagredus*, you seem to differ much from your self, for that you were wont to penetrate all things in an instant, and now you have overlook'd a fallacy couched in the experiment of the stick, which I my self have been able to discover: and this is the different manner of operating, in making the projection one while with the short sling and another while with the long one; for if you will have the stone fly out of the slit, you need not continue its motion uniformly, but at such time as it is at the swiftest, you are to stay your arm, and stop the velocity of the stick; whereupon the stone which was in its swiftest motion, flyeth out, and moveth with impetuosity: but now that stop cannot be made in the great stick, which by reason of its length and flexibility, doth not entirely obey the check of the arm, but continueth to accompany the stone for some space, and holdeth it in with so much less forces, and not as if you had with a stiff sling sent it going with a jerk: for if both the sticks or slings should be check'd by one and the same obstacle, I do believe they would fly aswell out of the one, as out of the other, howbeit their motions were equally swift.

SAGR. With the permission of *Salviatus*, I will answer something to *Simplicius*; in regard he hath addressed himself to me; and I say, that in his discourse there is somewhat good and somewhat bad: good, because it is almost all true; bad, because it doth not agree with our case: Truth is, that when that which carrieth the stones with velocity, shall meet with a check

*Granting the di-
urnal vertigo of
the Earth, & that
by some sudden stop
or obstacle it were
arrested, houses,
mountains them-
selves, and perhaps
the whole Globe
would be shaken in
pieces.*

check that is immoveable, they shall fly out with great impetuosity : the same effect following in that case, which we see dayly to fall out in a boat that running a swift course, runs a-ground, or meets with some sudden stop, for all those in the boat, being surprized, stumble forwards, and fall towards the part whither the boat steered. And in case the Earth should meet with such a check, as should be able to resist and arrest its *vertigo*, then indeed I do believe that not onely beasts, buildings and cities, but mountains, lakes and seas would overturn, and the globe it self would go near to shake in pieces; but nothing of all this concerns our present purpose, for we speak of what may follow to the motion of the Earth, it being turn'd round uniformly, and quietly about its own centre, howbeit with a great velocity. That likewise which you say of the slings, is true in part; but was not alledged by *Salviatus*, as a thing that punctually agreed with the matter whereof we treat, but onely, as an example, for so in gross it may prompt us in the more accurate consideration of that point, whether, the velocity increāsing at any rate, the cause of the projection doth increāse at the same rate : so that *v. g.* if a wheel of ten yards diameter, moving in such a manner that a point of its circumference will pass an hundred yards in a minute of an hour, and so hath an *impetus* able to extrude a stone, that same *impetus* shall be increāsed an hundred thousand times in a wheel of a million of yards diameter; the which *Salviatus* denieth, and I incline to his opinion; but not knowing the reason thereof, I have requested it of him, and stand impatiently expecting it.

SALV. I am ready to give you the best satisfaction, that my abilities will give leave : And though in my first discourse you thought that I had enquired into things estranged from our purpose, yet nevertheless I believe that in the sequel of the dispute, you will find that they do not prove so. Therefore let *Sagredus* tell me wherein he hath observed that the resistance of any moveable to motion doth consist.

SAGR. I see not for the present that the moveable hath any internal resistance to motion, unlesse it be its natural inclination and propension to the contrary motion, as in grave bodies; that have a propension to the motion downwards; the resistance is to the motion upwards; and I said an internal resistance, because of this, I think, it is you intend to speak, and not of the external resistances, which are many and accidental.

SALV. It is that indeed I mean, and your nimbleness of wit hath been too hard for my craftiness, but if I have been too short in asking the question, I doubt whether *Sagredus* hath been full enough in his answer to satisfie the demand; and whether there be not in the moveable, besides the natural inclination to the contrary

contrary term, another intrinsick and natural quality, which maketh it averse to motion. Therefore tell me again; do you not think that the inclination *v. g.* of grave bodies to move downwards, is equal to the resistance of the same to the motion of projection upwards?

The inclination of grave bodies to the motion downwards, is equal to their resistance to the motion upwards.

SAGR. I believe that it is exactly the same. And for this reason I see that two equal weights being put into a ballance; they do stand still in *equilibrium*, the gravity of the one resisting its being raised by the gravity wherewith the other pressing downwards would raise it.

SALV. Very well; so that if you would have one raise up the other, you must encrease the weight of that which depresseth, or lessen the weight of the other. But if the resistance to ascending motion consist onely in gravity, how cometh it to passe, that in ballances of unequal arms, to wit in the *Stiliard*, a weight sometimes of an hundred pounds, with its pression downwards, doth not suffice to raise up on of four pounds; that shall counterpoise with it, nay this of four descending shall raise up that of an hundred; for such is the effect of the pendant weight upon the weight which we would vveigh? If the resistance to motion resideth onely in the gravity, how can the arm with its vveight of four pounds onely, resist the vveight of a sack of wool, or bale of silk, which shall be eight hundred, or a thousand vveight; yea more, how can it overcome the sack with its moment, and raise it up? It must therefore be confest *Sagredus*, that here it maketh use of some other resistance, and other force, besides that of simple gravity.

* A portable ballance wherewith market-people weigh their commodities, giving it gravity by removing the weight farther from the cock: call'd by the Latines, *Campana trantina*.

SAGR. It must needs be so; therefore tell me vyhat this second virtue should be.

SALV. It is that vvhich vvas not in the ballance of equal arms; you see then vyhat variety there is in the *Stiliard*; and upon this doubtlesse dependeth the cause of the new effect.

SAGR. I think that your putting me to it a second time, hath made me remember something that may be to the purpose. In both these beams the businels is done by the weight, and by the motion; in the ballance, the motions are equal, and therefore the one weight must exceed it in gravity before it can move it; in the *stiliard*, the lesser weight will not move the greater, unless when this latter moveth little, as being hung at a lesser distance, and the other much, as hanging at a greater distance from the lacquet or cock. It is necessary therefore to conclude, that the lesser weight overcometh the resistance of the greater, by moving much, whilst the other is moved but little.

SALV. Which is as much as to say, that the velocity of the moveable less grave, compensateth the gravity of the moveable more grave and less swift.

SAGR.

The greater velocity exactly compensates the greater gravity.

SACK. But do you think that the velocity doth fully make good the gravity? that is, that the moment and force of a moveable of *u.g.* four pounds weight, is as great as that of one of an hundred weight, whensoever that the first hath an hundred degrees of velocity, and the later but four onely?

SALV. Yes doubtless, as I am able by many experiments to demonstrate: but for the present, let this onely of the stiliard suffice: in which you see that the light end of the beam is then able to sustain and equilibrate the great Wool sack, when its distance from the centre, upon which the stiliard resteth and turneth, shall so much exceed the lesser distance, by how much the absolute gravity of the Wool-sack exceedeth that of the pendent weight. And we see nothing that can cause this insufficiency in the great sack of Wool, to raise with its weight the pendent weight so much less grave, save the disparity of the motions which the one and the other should make, whilst that the Wool-sack by descending but one inch onely, will raise the pendent weight an hundred inches: (supposing that the sack did weigh an hundred times as much, and that the distance of the small weight from the centre of the beam were an hundred times greater, than the distance between the said centre and the point of the sacks suspension.) And again, the pendent weight its moving the space of an hundred inches, in the time that the sack moveth but one inch onely, is the same as to say, that the velocity of the motion of the little pendent weight, is an hundred times greater than the velocity of the motion of the sack. Now fix it in your beliefs, as a true and manifest axiom, that the resistance which proceedeth from the velocity of motion, compensateth that which dependeth on the gravity of another moveable: So that consequently, a moveable of one pound, that moveth with an hundred degrees of velocity, doth as much resist all obstruction, as another moveable of an hundred weight, whose velocity is but one degree onely. And two equal moveables will equally resist their being moved, if that they shall be moved with equal velocity: but if one be to be moved more swiftly than the other, it shall make greater resistance, according to the greater velocity that shall be conferred on it. These things being premised, let us proceed to the explanation of our Problem; and for the better understanding of things, let us make a short Scheme thereof. Let two unequal wheels be described about this centre A, [in Fig. 7.] and let the circumference of the lesser be B G, and of the greater C E H, and let the semidiameter A B C, be perpendicular to the Horizon; and by the points B and C, let us draw the right lined Tangents B F and C D, and in the arches B G and C E, take two equal parts B G and C E: and let the two wheels be supposed to be turn'd

round upon their centres with equal velocities, so as that two moveables, which suppose for example to be two stones placed in the points B and C, come to be carried along the circumferences B G and C E, with equal velocities; so that in the same time that the stone B shall have run the arch B G, the stone C will have past the arch C E. I say now, that the whirl or *vertigo* of the lesser wheel is much more potent to make the projection of the stone B, than the *vertigo* of the bigger wheel to make that of the stone C. Therefore the projection, as we have already declared, being to be made along the tangent, when the stones B and C are to separate from their wheels, and to begin the motion of projection from the points B and C, then shall they be extruded by the *impetus* conceived from the *vertigo* by (or along) the tangents B F and C D. The two stones therefore have equal impetuosities of running along the tangents B F and C D, and would run along the same, if they were not turn'd aside by some other force: is it not so *Sagredus*?

SAGR. In my opinion the business is as you say.

SALV. But what force, think you, should that be which averts the stones from moving by the tangents, along which they are certainly driven by the *impetus* of the *vertigo*.

SAGR. It is either their own gravity, or else some glutinous matter that holdeth them fast and close to the wheels.

SALV. But for the diverting of a moveable from the motion to which nature inciteth it, is there not required greater or lesser force, according as the deviation is intended to be greater or lesser? that is, according as the said moveable in its deviation hath a greater or lesser space to move in the same time?

SAGR. Yes certainly: for it was concluded even now, that to make a moveable to move; the movent virtue must be increased in proportion to the velocity wherewith it is to move.

SALV. Now consider, that for the deviating the stone upon the lesser wheel from the motion of projection, which it would make by the tangent B F, and for the holding of it fast to the wheel, it is required, that its own gravity draw it back the whole length of the secant F G, or of the perpendicular raised from the point G, to the line B F, whereas in the greater wheel the retraction needs to be no more than the secant D E, or the perpendicular let fall from the tangent D C to the point E, less by much than F G, and alwayes lesser and lesser according as the wheel is made bigger. And forasmuch as these retractions (as I may call them) are required to be made in equal times, that is, whilst the wheels passe the two equal arches B G and C E, that of the stone B, that is, the retraction F G ought to be more swift than the other D E; and therefore much greater force will be required for
B b holding

holding fast the stone B to its little wheel, than for the holding the stone C to its great one, which is as much as to say, that such a small thing will impede the extrusion in the great wheel, as will not at all hinder it in the little one. It is manifest therefore that the more the wheel augmenteth, the more the cause of the projection diminisheth.

SAGR. From this which I now understand, by help of your minute dissertation, I am induced to think, that I am able to satisfy my judgment in a very few words. For equal *impetus* being impressed on both the stones that move along the tangents, by the equal velocity of the two wheels, we see the great circumference, by means of its small deviation from the tangent, to go seconding, as it were, and in a fair way refraining in the stone the appetite, if I may so say, of separating from the circumference; so that any small retention, either of its own inclination, or of some glutination sufficeth to hold it fast to the wheel. Which, again, is not able to work the like effect in the little wheel, which but little prosecuting the direction of the tangent, seeketh with too much eagerness to hold fast the stone; and the restriction and glutination not being stronger than that which holdeth the other stone fast to the greater wheel, it breaks loose, and runneth along the tangent. Therefore I do not only finde that all those have erred, who have believed the cause of the projection to increase according to the augmentation of the *vertigo's* velocity; but I am further thinking, that the projection diminishing in the enlarging of the wheel, so long as the same velocity is retained in those wheels; it may possibly be true, that he that would make the great wheel extrude things like the little one, would be forced to increase them as much in velocity, as they increase in diameter, which he might do, by making them to finish their conversions in equal times; and thus we may conclude, that the Earths revolution of *vertigo* would be no more able to extrude stones, than any little wheel that goeth so slowly, as that it maketh but one turn in twenty four hours.

SALV. We will enquire no further into this point for the present: let it suffice that we have abundantly (if I deceive not myself) demonstrated the invalidity of the argument, which at first sight seemed very concluding, and was so held by very famous men: and I shall think my time and words well bestowed, if I have but gained some belief in the opinion of *Simplicius*, I will not say of the Earths mobility, but only that the opinion of those that believe it, is not so ridiculous and fond, as the rout of vulgar Philosophers esteem it.

SIMP. The answers hitherto produced against the arguments brought against this *Diurnal Revolution* of the Earth taken from
grave

* *Scrappar la cavazza, is to break the bridle.*

grave bodies falling from the top of a Tower, and from projections made perpendicularly upwards, or according to any inclination sideways towards the East, West, North, South, &c. have somewhat abated in me the antiquated incredulity I had conceived against that opinion: but other greater doubts run in my mind at this very instant, which I know not in the least how to free myself of, and haply you your self will not be able to resolve them; nay, its possible you may not have heard them, for they are very modern. And these are the objections of two Authours, that exprofesso write against *Copernicus*. Some of which are read in a little Tract of natural conclusions; The rest are by a great both Philosopher and Mathematician, inserted in a Treatise which he hath written in favour of *Aristotle*, and his opinion touching the inalterability of the Heavens, where he proveth, that not onely the Comets, but also the new stars, namely, that anno 1572. in *Cassiopeia*, and that anno 1604. in *Sagittarius* were not above the Spheres of the Planets, but absolutely beneath the concave of the Moon in the Elementary Sphere; and this he demonstrateth against *Tycho*, *Kepler*, and many other Astronomical Observators, and beateth them at their own weapon; to wit, the Doctrine of Parallaxes. If you like thereof, I will give you the reasons of both these Authours, for I have read them more than once, with attention; and you may examine their strength, and give your opinion thereon.

Other objections
of two modern Authors
against Copernicus.

SALV. In regard that our principal end is to bring upon the stage, and to consider what ever hath been said for, or against the two Systemes, *Ptolomaick*, and *Copernican*, it is not good to omit any thing that hath been written on this subject.

SIMP. I will begin therefore with the objections which I finde in the Treatise of Conclusions, and afterwards proceed to the rest. In the first place then, he bestoweth much paines in calculating exactly how many miles an hour a point of the terrestrial Globe situate under the Equinoctial, goeth, and how many miles are past by other points situate in other parallels: and not being content with finding out such motions in horary times, he findeth them also in a minute of an hour; and not contenting himself with a minute, he findes them also in a second minute; yea more, he goeth on to shew plainly, how many miles a Cannon bullet would go in the same time, being placed in the concave of the Lunar Orb, supposing it also as big as *Copernicus* himself representeth it, to take away all subterfuges from his adversary. And having made this most ingenious and exquisite supputation, he sheweth, that a grave body falling from thence above would consume more than six dayes in attaining to the centre of the Earth, to which all grave bodies naturally move. Now if by the absolute Divine

The first objection of the modern Author of the little tract of Conclusions.

A Cannon bullet would spend more than six days in falling from the Concave of the Moon to the centre of the Earth, according to the opinion of that modern Author of the Conclusions.

B b 2

Power

Power, or by some Angel, a very great Cannon bullet were carried up thither, and placed in our Zenith or vertical point, and from thence let go at liberty, it is in his, and also in my opinion, a most incredible thing that it, in descending downwards, should all the way maintain it self in our vertical line, continuing to turn round with the Earth, about its centre, for so many dayes, describing under the Equinoctial a Spiral line in the plain of the great circle it self: and under other Parallels, Spiral lines about Cones, and under the Poles falling by a simple right line. He, in the next place, stablisheth and confirmeth this great improbability by proving, in the way of interrogations, many difficulties impossible to be removed by the followers of *Copernicus*; and they are, if I do well remember-----

SALV. Take up a little, good *Simplicius*, and do not load me with so many novelties at once: I have but a bad memory, and therefore I must not go too fast. And in regard it cometh into my minde, that I once undertook to calculate how long time such a grave body falling from the concave of the Moon, would be in passing to the centre of the Earth, and that I think I remember that the time would not be so long; it would be fit that you shew us by what rule this Author made his calculation.

SIMP. He hath done it by proving his intent *à fortiori*, a sufficient advantage for his adversaries, supposing that the velocity of the body falling along the vertical line, towards the centre of the Earth, were equal to the velocity of its circular motion, which it made in the grand circle of the concave of the Lunar Orb. Which by equation would come to passe in an hour, twelve thousand six hundred German miles, a thing which indeed favours of impossibility: Yet nevertheless, to shew his abundant caution, and to give all advantages to his adversaries, he supposeth it for true, and concludeth, that the time of the fall ought however to be more than six dayes.

SALV. And is this the sum of his method? And doth he by this demonstration prove the time of the fall to be above six dayes?

SAGR. He thinks that he hath behaved himself too modestly; for that having it in the power of his will to give what velocity he pleased to such a descending body, and might aswell have made it six moneths, nay, six years in falling to the Earth, he is content with six dayes. But, good *Salviatus*, sharpen my appetite a little, by telling me in what manner you made your computation, in regard you say, that you have heretofore cast it up: for I am confident that if the question had not required some ingenuity in working it, you would never have applied your minde unto it.

SALV.

SALV. It is not enough, *Sagredus*, that the subjects be noble and great; but the businesse consists in handling it nobly. And who knoweth not, that in the dissection of the members of a beast, there may be discovered infinite wonders of provident and prudent Nature; and yet for one, that the Anatomist dissects, the butcher cuts up a thousand. Thus I, who am now seeking how to satisfie your demand, cannot tell with which of the two shapes I had best to appear on the Stage; but yet, taking heart from the example of *Simplicius*, his Authour, I will, without more delays, give you an account (if I have not forgot) how I proceeded. But before I go any further, I must not omit to tell you, that I much fear that *Simplicius* hath not faithfully related the manner how this his Authour found, that the Cannon bullet in coming from the concave of the Moon to the centre of the Earth, would spend more than six dayes: for if he had supposed that its velocity in descending was equal to that of the concave (as *Simplicius* saith he doth suppose) he would have shewn himself ignorant of the first, and more simple principles of Geometry; yea, I admire that *Simplicius*, in admitting the supposition which he speaketh of, doth not see the monstrous absurdity that is couched in it.

SIMP. Its possible that I may have erred in relating it; but that I see any fallacy in it, I am sure is not true.

SALV. Perhaps I did not rightly apprehend that which you said. Do you not say, that this Authour maketh the velocity of the bullet in descending equal to that which it had in turning round; being in the concave of the Moon, and that coming down with the same velocity, it would reach to the centre in six dayes?

SIMP. So as I think he writeth.

SALV. And do not you perceive a shamefull error therein? But questionlesse you dissemble it: For it cannot be, but that you should know that the semidiameter of the Circle is lesse than the sixth part of the circumference; and that consequently, the time in which the moveable shall passe the semidiameter, shall be lesse than the sixth part of the time; in which, being moved with the same velocity, it would passe the circumference; and that therefore the bullet descending with the velocity, where-with it moved in the concave, will arrive in lesse than four hours at the centre; supposing that in the concave one revolution should be consummate in twenty four hours, as he must of necessity have supposed it, for to keep it all the way in the same vertical line.

SIMP. Now I thorowly perceive the mistake: but yet I would not lay it upon him undeservedly, for its possible that I may

A shamefull error in the Argument taken from the bullets falling out of the Moons concave.

may have erred in rehearsing his Argument, and to avoid running into the same mistakes for the future, I could wish I had his Book; and if you had any body to send for it, I would take it for a great favour.

SAGR. You shall not want a Lacquey that will runne for it with all speed: and he shall do it presently, without losing any time; in the mean time *Salviatus* may please to oblige us with his computation.

SIMP. If he go, he shall finde it lie open upon my Desk, together with that of the other Author, who also argueth against *Copernicus*.

SAGR. We will make him bring that also for the more certainty: and in the interim *Salviatus* shall make his calculation: I have dispatch't away a messenger.

SALV. Above all things it must be considered, that the motion of descending grave bodies is not uniform, but departing from rest they go continually accelerating: An effect known and observed by all men, unlesse it be by the forementioned modern Author, who not speaking of acceleration, maketh it even and uniforme. But this general notion is of no avail, if it be not known according to what proportion this increase of velocity is made; a conclusion that hath been until our times unknown to all *Philosophers*; and was first found out & demonstrated by the *Academick*, our common friend, who in some of his * writings not yet published, but in familiarity shewn to me, and some others of his acquaintance he proveth, how that the acceleration of the right motion of grave bodies, is made according to the numbers uneven beginning *ab unitate*, that is, any number of equal times being assigned, if in the first time the moveable departing from rest shall have passed such a certain space, as for example, an ell, in the second time it shall have passed three ells, in the third five, in the fourth seven, and so progressively, according to the following odd numbers; which in short is the same, as if I should say, that the spaces passed by the moveable departing from its rest, are unto each other in proportion double to the proportion of the times, in which those spaces are measured; or we will say, that the spaces passed are to each other, as the squares of their times.

SAGR. This is truly admirable: and do you say that there is a Mathematical demonstration for it?

SALV. Yes, purely Mathematical; and not onely for this, but for many other very admirable passions, pertaining to natural motions, and to projects also, all invented, and demonstrated by Our Friend, and I have seen and considered them all to my very great content and admiration, seeing a new compleat Doctrine to spring up touching a subject, upon which have been written hundreds of

Volumes;

An exact compute of the time of the fall of the Cannon bullet from the Moons concave to the Earths centre.

* The Author.

* By these Writings, he every where meanes his Dialogues, *De motu*, which I promise to give you in my second Volume.

Acceleration of the natural motion of grave bodies is made according to the odde numbers beginning at unity.

The spaces past by the falling grave body are as the squares of their times.

An intire and new Science of the Academick concerning local motion.

Volumes; and yet not so much as one of the infinite admirable conclusions that those his writings contain, hath ever been observed, or understood by any one, before *Our Friend* made them out.

SAGR. You make me lose the desire I had to understand more in our disputes in hand, onely that I may hear some of those demonstrations which you speak of; therefore either give them me presently, or at least promise me upon your word, to appoint a particular conference concerning them, at which *Simplicius* also may be present, if he shall have a mind to hear the passions and accidents of the primary effect in Nature.

SIMP. I shall undoubtedly be much pleased therewith, though indeed, as to what concerneth Natural Philosophy, I do not think that it is necessary to descend unto minute particularities, a general knowledge of the definition of motion, and of the distinction of natural and violent, even and accelerate, and the like, sufficing. For if this were not sufficient, I do not think that *Aristotle* would have omitted to have taught us what ever more was necessary.

SALV. It may be so. But let us not lose more time about this, which I promise to spend half a day apart in, for your satisfaction; nay, now I remember, I did promise you once before to satisfy you herein. Returning therefore to our begun calculation of the time, wherein the grave cadent body would pass from the concave of the Moon to the centre of the Earth, that we may not proceed arbitrarily and at random, but with a Logical method, we will first attempt to ascertain our selves by experiments often repeated, in how long time a ball *v. g.* of Iron descendeth to the Earth from an altitude of an hundred yards.

SAGR. Let us therefore take a ball of such a determinate weight, and let it be the same wherewith we intend to make the computation of the time of descent from the Moon.

SALV. This is not material, for that a ball of one, of ten, of an hundred, of a thousand pounds, will all measure the same hundred yards in the same time.

SIMP. But this I cannot believe, nor much less doth *Aristotle* think so; who writeth, that the velocities of descending grave bodies, are in the same proportion to one another, as their gravities.

SALV. If you will admit this for true, *Simplicius*, you must believe also, that two balls of the same matter, being let fall in the same moment, one of an hundred pounds, and another of one, from an altitude of an hundred yards, the great one arriveth at the ground, before the other is descended but one yard onely. Now bring your fancy, if you can, to imagine, that you see the great ball

The error of Aristotle in affirming, falling grave bodies to move according to the proportion of their gravities.

ball got to the ground, when the little one is ſtill within leſs than a yard of the top of the Tower.

SAGR. That this propoſition is moſt falſe, I make no doubt in the world; but yet that yours is abſolutely true, I cannot well aſſure my ſelf: nevertheless, I believe it, ſeeing that you ſo reſolutely affirm it; which I am ſure you would not do, if you had not certain experience, or ſome clear demonſtration thereof.

(a)(b) Note that theſe Calculations are made in Italian weights and meaſures. And 100 pounds *Haverdu-poſe* make 131 *l.* Florentine. And 100 English yards makes 150 $\frac{2}{3}$ Braces Florent. ſo that the brace or yard of our Author is $\frac{3}{4}$ of our yard.

SALV. I have both; and when we ſhall handle the buſineſs of motions apart, I will communicate them: in the interim, that we may have no more occaſions of interrupting our diſcourſe, we will ſuppoſe, that we are to make our computation upon a ball of Iron of an hundred (a) pounds, the which by reiterated experiments deſcendeth from the altitude of an hundred (b) yards, in five ſecond-minutes of an hour. And becauſe, as we have ſaid, the ſpaces that are meaſured by the cadent moveable, increaſe in double proportion; that is, according to the ſquares of the times, being that the time of one firſt-minute is duodecuple to the time of five ſeconds, if we multiply the hundred yards by the ſquare of 12, that is by 144, we ſhall have 14400, which ſhall be the number of yards that the ſame moveable ſhall paſs in one firſt-minute of an hour: and following the ſame rule becauſe one hour is 60 minutes, multiplying 14400, the number of yards paſt in one minute, by the ſquare of 60, that is, by 3600, there ſhall come forth 51840000, the number of yards to be paſſed in an hour, which make 17280 miles. And deſiring to know the ſpace that the ſaid ball would paſs in 4 hours, let us multiply 17280 by 16, (which is the ſquare of 4) and the product will be 276480 miles: which number is much greater than the diſtance from the Lunar concave to the centre of the Earth, which is but 196000 miles, making the diſtance of the concave 56 ſemidiameters of the Earth, as that modern Author doth; and the ſemidiameter of the Earth 3500 miles, of 3000 *Braces* to a mile, which are our Italian miles.

* The Italian meaſure which I commonly tranſlate yards.

† The Italian mile is $\frac{1800}{11}$ of our mile.

Therefore, *Simplicius*, that ſpace from the concave of the Moon to the centre of the Earth, which your Accomptant ſaid could not be paſſed under more than ſix days, you ſee that (computing by experience, and not upon the fingers ends) that it ſhall be paſſed in much leſs than four hours; and making the computation exact, it ſhall be paſſed by the moveable in 3 hours, 22 min. prim. and 4 ſeconds.

SAGR. I beſeech you, dear Sir, do not defraud me of this exact calculation, for it muſt needs be very excellent.

SALV. So indeed it is: therefore having (as I have ſaid) by diligent tryal obſerved, that ſuch a moveable paſſeth in its deſcent, the height of 100 yards in 5 ſeconds of an hour, we will ſay, if 100 yards are paſſed in 5 ſeconds; in how many ſeconds ſhall

58800000

588000000 yards (for so many are in 56 diameters of the Earth) be passed? The rule for this work is, that the third number must be multiplied by the square of the second, of which doth come 14700000000, which ought to be divided by the first, that is, by 100, and the root square of the quotient, that is, 12124 is the number sought, namely 12124 *min. secun.* of an hour, which are 3 hours, 22 *min. prim.* and 4 seconds.

SAGR. I have seen the working, but I know nothing of the reason for so working, nor do I now think it a time to ask it.

SALV. Yet I will give it, though you do not ask it, because it is very easie. Let us mark these three numbers with the Letters

A first, B second, C third. A and C are the numbers of the spaces, B is the number of the time; the fourth number is sought, of the time also. And because we know, that look what proportion the space A, hath to the space C, the same proportion shall the square of the time B have to the square of the time, which is sought.

100. <i>secun.</i> 588000000.	
A	B C 25
1	14700000000
	35956
22	10
241	60 12124
	202
2422	3
24240	

Therefore by the Golden Rule, let the number C be multiplied by the square of the number B, and let the product be divided by the number A, and the quotient shall be the square of the number sought, and its square root shall be the number it self that is sought. Now you see how easie it is to be understood.

SAGR. So are all truths, when once they are found out, but the difficulty lyeth in finding them. I very well apprehend it, and kindly thank you. And if there remain any other curiosity touching this point, I pray you let us hear it; for if I may speak my mind, I will with the favour of *Simplicius*, that from your discourses I alwayes learn some new motion, but from those of his Philosophers, I do not remember that I have learn't any thing of moment.

SALV. There might be much more said touching these local motions; but according to agreement, we will reserve it to a particular conference; and for the present I will speak something touching the Author named by *Simplicius*, who thinketh he hath given a great advantage to the adverse party in granting that, that Canon bullet in falling from the concave of the Moon may descend with a velocity equal to the velocity wherewith it would

C e

turn

*The falling move-
able if it move with
a degree of veloci-
ty acquired in a
like time with an
uniform motion, it
shall pass a space
double to that pas-
sed with the acce-
lerated motion.*

turn round, staying there above; and moving along with the diurnal conversion. Now I tell him, that that same ball falling from the concave unto the centre, will acquire a degree of velocity much more than double the velocity of the diurnal motion of the Lunar concave; and this I will make out by solid and not impertinent suppositions. You must know therefore that the grave body falling and acquiring all the way new velocity according to the proportion already mentioned, hath in any whatsoever place of the line of its motion such a degree of velocity, that if it should continue to move therewith, uniformly without farther encreasing it; in another time like to that of its descent, it would passe a space double to that passed in the line of the precedent motion of descent. And thus for example, if that ball in coming from the concave of the Moon to its centre hath spent three hours, 22 min. *prim.* and 4 seconds, I say, that being arrived at the centre, it shall find it self constituted in such a degree of velocity, that if with that, without farther encreasing it, it should continue to move uniformly, it would in other 3 hours, 22 min. *prim.* and 4 seconds, passe double that space, namely as much as the whole diameter of the Lunar Orb; and because from the Moons concave to the centre are 196000 miles, which the ball passeth in 3 hours 22 *prim.* min. and 4 seconds, therefore (according to what hath been said) the ball continuing to move with the velocity which it is found to have in its arrival at the centre, it would passe in other 3 hours 22 min. *prim.* and 4 seconds, a space double to that, namely 392000 miles; but the same continuing in the concave of the Moon, which is in circuit 1232000 miles, and moving therewith in a diurnal motion, it would make in the same time, that is in 3 hours 22 min. *prim.* and 4 seconds, 172880 miles, which are fewer by many than the half of the 392000 miles. You see then that the motion in the concave is not as the modern Author saith, that is, of a velocity impossible for the falling ball to partake of, &c.

SALV. The discourse would pass for current, and would give me full satisfaction, if that particular was but salved; of the moving of the moveable by a double space to that passed in falling in another time equal to that of the descent, in case it doth continue to move uniformly with the greatest degree of velocity acquired in descending. A proposition which you also once before supposed as true, but never demonstrated.

SALV. This is one of the demonstrations of *Our Friend*, and you shall see it in due time; but for the present, I will with some conjectures (not teach you any thing that is new, but) remember you of a certain contrary opinion, and shew you, that it may haply so be. A bullet of lead hanging in a long and fine thread fastened to the roof;

roof, if we remove it far from perpendicularity, and then let it go, have you not observed that, it declining, will pass freely, and well near as far to the other side of the perpendicular?

SAGR. I have observed it very well, and find (especially if the plummet be of any considerable weight) that it riseth so little less than it descended, so that I have sometimes thought, that the ascending arch is equal to that descending, and thereupon made it a question whether the vibrations might not perpetuate themselves; and I believe that they might, if that it were possible to remove the impediment of the Air, which resisting penetration, doth some small matter retard and impede the motion of the *pendulum*, though indeed that impediment is but small in favour of which opinion the great number of vibrations that are made before the moveable wholly ceaseth to move, seems to plead.

SALV. The motion would not be perpetual, *Sagredus*, although the impediment of the Air were totally removed, because there is another much more abstruse,

SAGR. And what is that? as for my part I can think of no other?

SALV. You will be pleased when you hear it, but I shall not tell it you till anon: in the mean time, let us proceed. I have proposed the observation of this *Pendulum*, to the intent, that you should understand, that the *impetus* acquired in the descending arch, where the motion is natural, is of it self able to drive the said ball with a violent motion, as far on the other side in the like ascending arch; if so, I say, of it self, all external impediments being removed: I believe also that every one takes it for granted, that as in the descending arch the velocity all the way increaseth, till it come to the lowest point, or its perpendicularity; so from this point, by the other ascending arch, it all the way diminisheth, untill it come to its extreme and highest point, and diminishing with the same proportions, wherewith it did before increase, so that the degrees of the velocities in the points equidistant from the point of perpendicularity, are equal to each other. Hence it seemeth to me (arguing with all due modesty) that I might easily be induced to believe, that if the Terrestrial Globe were bored thorow the centre, a Canon bullet descending through that Well, would acquire by that time it came to the centre, such an impulse of velocity, that, it having passed beyond the centre, would spring it upwards the other way, as great a space, as that was wherewith it had descended, all the way beyond the centre diminishing the velocity with decreasements like to the increasements acquired in the descent: and the time spent in this second motion of ascent, I believe, would be equal to the time of descent. Now if the moveable by diminishing that its greatest degree of velocity which it

The motion of grave penduli might be perpetuated, impediments being removed.

If the Terrestrial Globe were perforated, a grave body descending by that bore, would pass and ascend as far beyond the centre, as it did descend.

had in the centre, successively until it come to total extinction, do carry the moveable in such a time such a certain space, as it had gone in such a like quantity of time, by the acquist of velocity from the total privation of it until it came to that its greatest degree; it seemeth very reasonable, that if it should move always with the said greatest degree of velocity it would pass, in such another quantity of time, both those spaces. For if we do but in our mind successively divide those velocities into rising and falling degrees, as *v. g.* these numbers in the margine; so that the first sort unto 10 be supposed the increasing velocities, and the others unto 1, be the decreasing; and let those of the time of the descent, and the others of the time of the ascent being added all together, make as many, as if one of the two sums of them had been all of the greatest degrees, and therefore the whole space passed by all the degrees of the increasing velocities, and decreasing, (which put together is the whole diameter) ought to be equal to the space passed by the greatest velocities, that are in number half the aggregate of the increasing and decreasing velocities. I know that I have but obscurely expressed my self, and I wish I may be understood.

SAGR. I think I understand you very well; and also that I can in a few words shew, that I do understand you. You had a mind to say, that the motion begining from rest, and all the way increasing the velocity with equal augmentations, such as are those of continue numbers begining at 1, rather at 0, which representeth the state of rest, disposed as in the margine: and continued at pleasure, so as that the least degree may be 0, and the greatest *v. g.* 5, all these degrees of velocity wherewith the moveable is moved, make the sum of 15; but if the moveable should move with as many degrees in number as these are, and each of them equal to the biggest, which is 5, the aggregate of all these last velocities would be double to the others, namely 30. And therefore the moveable moving with a like time, but with uniform velocity, which is that of the highest degree 5, ought to pass a space double to that which it passeth in the accelerate time, which beginneth at the state of rest.

SALV. According to your quick and piercing way of apprehending things, you have explained the whole business with more plainness than I my self; and put me also in mind of adding something more: for in the accelerate motion, the augmentation being continual, you cannot divide the degrees of velocity, which continually increase, into any determinate number, because changing every moment, they are evermore infinite. Therefore we shall be the better able to exemplifie our intentions by describing a Triangle, which let be this ABC, [*in Fig. 8.*] taking in the side

side A C, as many equal parts as we please, A D, D E, E F, F G, and drawing by the points D, E, F, G, right lines parallel to the base B C. Now let us imagine the parts marked in the line A C, to be equal times, and let the parallels drawn by the points D, E, F, G, represent unto us the degrees of velocity accelerated, and increasing equally in equal times; and let the point A be the state of rest, from which the moveable departing, hath v. g. in the time A D, acquired the degree of velocity D H, in the second time we will suppose, that it hath increased the velocity from D H, as far as to E I, and so supposing it to have grown greater in the succeeding times, according to the increase of the lines F K, G L, &c. but because the acceleration is made continually from moment to moment, and not disjunctly from one certain part of time to another; the point A being put for the lowest moment of velocity, that is, for the state of rest, and A D for the first instant of time following; it is manifest, that before the acquit of the degree of velocity D H, made in the time A D, the moveable must have past by infinite other lesser and lesser degrees gained in the infinite instants that are in the time D A, answering the infinite points that are in the line D A; therefore to represent unto us the infinite degrees of velocity that precede the degree D H, it is necessary to imagine infinite lines successively lesser and lesser, which are supposed to be drawn by the infinite points of the line D A, and parallels to D H, the which infinite lines represent unto us the superficies of the Triangle A H D, and thus we may imagine any space passed by the moveable, with a motion which beginning at rest, goeth uniformly accelerating, to have spent and made use of infinite degrees of velocity, increasing according to the infinite lines that beginning from the point A, are supposed to be drawn parallel to the line H D, and to the rest I E, K F, L G, the motion continuing as far as one will.

Now let us compleat the whole Parallelogram A M B C, and let us prolong as far as to the side thereof B M, not only the Parallels marked in the Triangle, but those infinite others imagined to be drawn from all the points of the side A C; and like as B C, was the greatest of those infinite parallels of the Triangle, representing unto us the greatest degree of velocity acquired by the moveable in the accelerate motion, and the whole superficies of the said Triangle, was the mass and sum of the whole velocity, wherewith in the time A C it passed such a certain space, so the parallelogram is now a mass and aggregate of a like number of degrees of velocity, but each equal to the greatest B C, the which mass of velocities will be double to the mass of the increasing velocities in the Triangle, like as the said Parallelogram is double to the Triangle: and therefore if the moveable, that falling did make use of

The acceleration of grave bodies naturally descending, increaseth from moment to moment.

of the accelerated degrees of velocity, answering to the triangle *ABC*, hath passed in such a time such a space, it is very reasonable and probable, that making use of the uniform velocities answering to the parallelogram, it shall passe with an even motion in the same time a space double to that passed by the accelerate motion.

SAGR. I am entirely satisfied. And, if you call this a probable Discourse, what shall the necessary demonstrations be? I wish that in the whole body of common Philosophy, I could find one that was but thus concludent.

SIMP. It is not necessary in natural Philosophy to seek exquisite Mathematical evidence.

SAGR. But this point of motion, is it not a natural question? and yet I cannot find that *Aristotle* hath demonstrated any the least accident of it. But let us no longer divert our intended Theme, nor do you fail, I pray you *Salviatus*, to tell me that which you hinted to me to be the cause of the *Pendulum's* quiescence, besides the resistance of the *Medium* to penetration.

SALV. Tell me; of two *penduli* hanging at unequal distances, doth not that which is fastned to the longer threed make its vibrations more seldome?

SAGR. Yes, if they be moved to equall distances from their perpendicularity.

SALV. This greater or lesse elongation importeth nothing at all, for the same *pendulum* alwayes maketh its reciprocations in equall times, be they longer or shorter, that is, though the *pendulum* be little or much removed from its perpendicularity, and if they are not absolutely equal, they are insensibly different, as experience may shew you; and though they were very unequal, yet would they not discountenance, but favour our cause. Therefore let us draw the perpendicular *AB* [*in Fig. 9.*] and hang from the point *A*, upon the threed *AC*, a plummet *C*, and another upon the same threed also, which let be *E*, and the threed *AC*, being removed from its perpendicularity, and then letting go the plummet *C* and *E*, they shall move by the arches *CBD*, *EGF*, and the plummet *E*, as hanging at a lesser distance, and withall, as (by what you said) lesse removed, will return back again faster, and make its vibrations more frequent than the plummet *C*, and therefore shall hinder the said plummet *C*, from running so much farther towards the term *D*, as it would do, if it were free: and thus the plummet *E* bringing unto it in every vibration continuall impediment, it shall finally reduce it to quiescence. Now the same threed, (taking away the middle plummet) is a composition of many grave *penduli*, that is, each of its parts is such a *pendulum* fastned neerer and neerer to the point *A*, and therefore disposed

In natural Sciences it is not necessary to seek Mathematical evidence.

The pendulum hanging at a longer threed, maketh its vibrations more seldome than the pendulum hanging at a shorter threed.

The vibrations of the same pendulum are made with the same frequency, whether they be small or great.

The cause which impedeth the pendulum, and retaineth it to rest.

fed to make its vibrations successively more and more frequent; and consequently is able to bring a continual impediment to the plummet C; and for a proof that this is so, if we do but observe the thread A C, we shall see it distended not directly, but in an arch; and if instead of the thread we take a chain, we shall discern the effect more perfectly; and especially removing the gravity C, to a considerable distance from the perpendicular A B, for that the chain being composed of many loose particles, and each of them of some weight, the arches A E C, and A F D, will appear notably incurvated. By reason therefore, that the parts of the chain, according as they are neerer to the point A, desire to make their vibrations more frequent, they permit not the lower parts of the said chain to swing so far as naturally they would: and by continual detracting from the vibrations of the plummet C, they finally make it cease to move, although the impediment of the air might be removed.

The thread or chain to which a pendulum is fastened, maketh an arch, and doth not stretch it self streight out in its vibrations.

SAGR. The books are now come; here take them *Simplicius*, and find the place you are in doubt of.

SIMP. See, here it is where he beginneth to argue against the diurnal motion of the Earth, he having first confuted the annual. *Motus terræ annuus asserere Copernicanos cogit conversionem ejusdem quotidianam; alias idem terræ Hemisphærium continenter ad Solem esset conversum obumbrato semper averso.* [In English thus:] The annual motion of the Earth doth compell the Copernicans to asser the daily conversion thereof; otherwise the same Hemisphere of the Earth would be continually turned towards the Sun, the shady side being always averse. And so one half of the Earth would never come to see the Sun.

SALV. I find at the very first sight, that this man hath not rightly apprehended the *Copernican Hypothesis*, for if he had but taken notice how he alwayes makes the Axis of the terrestrial Globe perpetually parallel to it self, he would not have said, that one half of the Earth would never see the Sun, but that the year would be one entire natural day, that is, that thorow all parts of the Earth there would be six moneths day, and six moneths night, as it now befalleth to the inhabitants under the Pole, but let this mistake be forgiven him, and let us come to what remaineth.

SIMP. It followeth, *Hanc autem gyrationem Terræ impossibilem esse sic demonstramus.* Which speaks in English thus: That this gyration of the Earth is impossible we thus demonstrate. That which ensueth is the declaration of the following figure, wherein is delineated many descending grave bodies, and ascending light bodies, and birds that fly to and again in the air, &c.

SAGR. Let us see them, I pray you. Oh! what fine figures, what

what birds, what balls, and what other pretty things are here?

SYMP. These are balls which come from the concave of the Moon.

SAGR. And what is this?

SYMP. This is a kind of Shell-fish, which here at *Venice* they call *buovoli*; and this also came from the Moons concave.

SAGR. Indeed, it seems then, that the Moon hath a great power over these Oyster-fishes, which we call * *armed fishes*.

* *Pesci armati, or armati.*

SYMP. And this is that calculation, which I mentioned, of this Journey in a natural day, in an hour, in a first minute, and in a second; which a point of the Earth would make placed under the Equinoctial, and also in the parallel of 48 gr. And then followeth this, which I doubted I had committed some mistake in reciting; therefore let us read it. *His positis, necesse est, terra circulariter mota, omnia ex aëre eidem, &c. Quod si hasce pilas aequales ponemus pondere, magnitudine, gravitate, & in concavo Sphaerae Lunaris positas libero descensui permittamus, si motum deorsum aequemus celeritate motui circum, (quod tamen secus est, cum pila A, &c.) elabentur minimum (ut multum cedamus adversariis) dies sex: quo tempore sexies circa terram, &c. [In English thus.]* These things being supposed, it is necessary, the Earth being circularly moved, that all things from the air to the same, &c. So that if we suppose these balls to be equal in magnitude and gravity, and being placed in the concave of the Lunar Sphere, we permit them a free descent, and if we make the motion downwards equal in velocity to the motion about, (which nevertheless is otherwise, if the ball A, &c.) they shall be falling at least (that we may grant much to our adversaries) six dayes; in which time they shall be turned six times about the Earth, &c.

SALV. You have but too faithfully cited the argument of this person. From hence you may collect *Simplicius*, with what caution they ought to proceed, who would give themselves up to believe others in those things, which perhaps they do not believe themselves. For me thinks it a thing impossible, but that this Author was advised, that he did design to himself a circle, whose diameter (which amongst Mathematicians, is lesse than one third part of the circumference) is above 72 times bigger than it self: an error that affirmeth that to be considerably more than 200, which is lesse than one.

SAGR. It may be, that these Mathematical proportions, which are true in abstract, being once applied in concrete to Physical and Elementary circles, do not so exactly agree. And yet, I think, that the Cooper, to find the semidiameter of the bottom, which he is to fit to the Cask, doth make use of the rule of Mathematicians in abstract, although such bottomes be things meerly material, and

and concrete : therefore let *Simplicius* plead in excuse of this Author ; and whether he thinks that the Physicks can differ so very much from the Mathematicks.

SIMP. The subtractions are in my opinion insufficient to salve this difference, which is so extreamly too great to be reconciled : and in this case I have no more to say but that, *Quandoque bonus dormitet Homerus*. But supposing the calculation of * *Salviatus* to be more exact, and that the time of the descent of the ball were no more than three hours ; yet me thinks, that coming from the concave of the Moon, which is so great a distance off, it would be an admirable thing, that it should have an instinct of maintaining it self all the way over the self-same point of the Earth, over which it did hang in its departure thence, and not rather be left a very great way behind.

* Not *Sagredus*, as the Latine have it.

SALV. The effect may be admirable, and not admirable, but natural and ordinary, according as the things precedent may fall out. For if the ball (according to the Author's suppositions) whilst it staid in the concave of the Moon, had the circular motion of twenty-four hours together with the Earth, and with the rest of the things contained within the said Concave ; that very vertue which made it turn round before its descent, will continue it in the same motion in its descending. And so far it is from not keeping pace with the motion of the Earth, and from staying behind, that it is more likely to out-go it ; being that in its approaches to the Earth, the motion of gyration is to be made with circles continually lesser and lesser ; so that the ball retaining in it self that self-same velocity which it had in the concave, it ought to anticipate, as I have said, the *vertigo* or conversion of the Earth. But if the ball in the concave did want that circulation, it is not obliged in descending to maintain it self perpendicularly over that point of the Earth, which was just under it when the descent began. Nor will *Copernicus*, or any of his followers affirm the same.

SIMP. But the Author maketh an objection, as you see, demanding on what principle this circular motion of grave and light bodies, doth depend : that is, whether upon an internal or an external principle.

SALV. Keeping to the Probleme of which we speak, I say, that that very principle which made the ball turn round, whilst it was in the Lunar concave, is the same that maintaineth also the circulation in the descent : yet I leave the Author at liberty to make it internal or external at his pleasure.

SIMP. The Author proveth, that it can neither be inward nor outward.

SALV. And I will say then, that the ball in the concave did

D d

not

not move, and so he shall not be bound to shew how that in descending it continueth all the way vertically over one point, for that it will not do any such thing.

SIMP. Very well; But if grave bodies, and light can have no principle, either internal or external of moving circularly, than neither can the terrestrial Globe move with a circular motion: and thus you have the intent of the Author.

SALV. I did not say, that the Earth had no principle, either interne, or externe to the motion of gyration, but I say, that I do not know which of the two it hath; and yet my not knowing it hath not a power to deprive it of the same; but if this Author can tell by what principle other mundane bodies are moved round, of whose motion there is no doubt; I say, that that which maketh the Earth to move, is a vertue, like to that, by which *Mars* and *Jupiter* are moved, and wherewith he believes that the starry Sphere it self also doth move; and if he will but assure me, who is the mover of one of these moveables, I will undertake to be able to tell him who maketh the Earth to move. Nay more; I will undertake to do the same; if he can but tell me, who moveth the parts of the Earth downwards.

SIMP. The cause of this is most manifest, and every one knows that it is gravity.

SALV. You are out, *Simplicius*, you should say, that every one knowes, that it is called Gravity: but I do not question you about the name, but the essence of the thing, of which essence you know not a tittle more than you know the essence of the mover of the stars in gyration; unlesse it be the name that hath been put to this, and made familiar, and domestical, by the many experiences which we see thereof every hour in the day, : but not as if we really understand any more, what principle or vertue that is which moveth a stone downwards, than we know who moveth it upwards, when it is separated from the projicient, or who moveth the Moon round, except (as I have said) onely the name, which more particularly and properly we have assigned to the motion of descent, namely, Gravity; whereas for the cause of circular motion, in more general termes, we assign the *Vertue impressed*, and call the same an *Intelligence*, either assisting, or informing; and to infinite other motions we ascribe Nature for their cause.

SIMP. It is my opinion, that this Author asketh far lesse than that, to which you deny to make answer; for he doth not ask what is nominally and particularly the principle that moveth grave and light bodies circularly; but whatsoever it be, he desireth to know, whether you think it intrinsical, or extrinsical: For howbeit, &c. I do not know, what kind of thing that gravity is, by which the Earth descendeth; yet I know that it is an intern
princi-

We know no more who moveth grave bodies downwards, than who moveth the Stars round, nor know we any thing of these causes, more than the names imposed on them by us.

principle, seeing that if it be not hindered, it moveth spontaneously: and on the contrary, I know that the principle which moveth it upwards, is external; although that I do not know, what thing that vertue is, impressed on it by the projicient.

SALV. Into how many questions must we excurre, if we would decide all the difficulties, which successively have dependance one upon another! You call that an external (and you also call it a preternatural and violent) principle, which moveth the grave project upwards; but its possible that it may be no lesse interne and natural, than that which moveth it downwards; it may peradventure be called external and violent, so long as the moveable is joynd to the projicient; but being separated, what external thing remaineth for a mover of the arrow, or ball? In summe, it must necessarily be granted, that that vertue which carrieth such a moveable upwards, is no lesse interne, than that which moveth it downwards; and I think the motion of grave bodies ascending by the *impetus* conceived, to be altogether as natural, as the motion of descent depending on gravity.

The vertue which carrieth graves projects upwards, is no lesse natural to them, than the gravity which moveth them downwards.

SIMP. I will never grant this; for the motion of descent hath its principle internal, natural, and perpetual, and the motion of ascent hath its principle externe, violent, and finite.

SALV. If you refuse to grant me, that the principles of the motions of grave bodies downwards and upwards, are equally interne and natural; what would you do, if I should say, that they may also be the same in number?

Contrary principles cannot naturally reside in the same subject.

SIMP. I leave it to you to judge.

SALV. But I desire you your self to be the Judge: Therefore tell me, Do you believe that in the same natural body, there may reside interne principles, that are contrary to one another?

SIMP. I do verily believe there cannot.

SALV. What do you think to be the natural inclination of Earth, of Lead, of Gold, and in sum, of the most ponderous matters; that is, to what motion do you believe that their interne principle draweth them?

SIMP. To that towards the centre of things grave, that is, to the centre of the Universe, and of the Earth, whither, if they be not hindered, it will carry them.

SALV. So that, if the Terrestrial Globe were bored thorow, and a Well made that should passe through the centre of it, a Cannon bullet being let fall into the same, as being moved by a natural and intrinsick principle, would passe to the centre; and it would make all this motion spontaneously, and by intrinsick principle, is it not so?

SIMP. So I verily believe.

SALV. But when it is arrived at the centre, do you think that

D d 2

it

it will passe any further, or else that there it would immediately stand still, and move no further?

SIMP. I believe that it would continue to move a great way further.

The natural motion changeth it selfe into that which is called preternatural and violent.

SALV. But this motion beyond the centre, would it not be upwards, and according to your assertion preternatural, and violent? And yet on what other principle do you make it to depend, but only upon the self same, which did carry the ball to the centre, and which you called intrinsecal, and natural? Finde, if you can, another external projicient, that overtaketh it again to drive it upwards. And this that hath been said of the motion thorow the centre, is also seen by us here above; for the interne *impetus* of a grave body falling along a declining superficies, if the said superficies be reflected the other way, it shall carry it, without a jot interrupting the motion, also upwards. A ball of lead that hangeth by a thread, being removed from its perpendicularity, descendeth spontaneously, as being drawn by its internal inclination, and without any interposure of rest, passeth beyond the lowest point of perpendicularity: and without any additional mover, moveth upwards. I know that you will not deny; but that the principle of grave bodies that moyeth them downwards, is no less natural, and intrinsecal, than that principle of light bodies, vvhich moveth them upwards; so that I propose to your consideration a ball of lead, vvhich descending through the Air from a great altitude, and so moving by an intern principle, and comming to a depth of vvater, continueth its descent, and without any other externe mover, submergeth a great vvay; and yet the motion of descent in the vvater is preternatural unto it; but yet nevertheless dependeth on a principle that is internal, and not external to the ball. You see it demonstrated then, that a moveable may be moved by one and the same internal principle, with contrary motions.

SIMP. I believe there are solutions to all these objections, though for the present I do not remember them; but however it be, the Author continueth to demand, on what principle this circular motion of grave and light bodies dependeth; that is, whether on a principle internal, or external; and proceeding forwards, sheweth, that it can be neither on the one, nor on the other, saying; *Si ab externo; Deusne illum excitat per continuum miraculum? an verò Angelus, an aër? Et hunc quidem multi assignant. Sed contra* — [In English thus] If from an externe principle; Whether God doth not excite it by a continued Miracle? or an Angel, or the Air? And indeed many do assign this. But on the contrary —

SALV. Trouble not your self to read his argument; for I am none

none of those who ascribe that principle to the ambient air. As to the Miracle, or an Angel, I should rather incline to this side; for that which taketh beginning from a Divine Miracle, or from an Angelical operation; as for instance, the transportation of a Cannon ball or bullet into the concave of the Moon, doth in all probability depend on the vertue of the same principle for performing the rest. But, as to the Air, it serveth my turn, that it doth not hinder the circular motion of the moveables, which we did suppose to move thorow it. And to prove that, it sufficeth (nor is more required) that it moveth with the same motion, and finisheth its circulations with the same velocity, that the Terrestrial Globe doth.

SIMP. And he likewise makes his opposition to this also; demanding who carrieth the air about, Nature, or Violence? And proveth, that it cannot be Nature, alledging that that is contrary to truth, experience, and to Copernicus himself.

SALV. It is not contrary to Copernicus in the least, who writeth no such thing; and this Author ascribes these things to him with two excessive courtesie. It's true, he saith, and for my part I think he saith well, that the part of the air neer to the Earth, being rather a terrestrial evaporation, may have the same nature, and naturally follow its motion; or, as being contiguous to it, may follow it in the same manner, as the Peripateticks say, that the superiour part of it, and the Element of fire, follow the motion of the Lunar Concave, so that it lyeth upon them to declare, whether that motion be natural, or violent.

SIMP. The Author will reply, that if Copernicus maketh only the inferiour part of the Air to move, and supposeth the upper part thereof to want the said motion, he cannot give a reason, how that quiet air can be able to carry those grave bodies along with it, and make them keep pace with the motion of the Earth.

SALV. Copernicus will say, that this natural propension of the elementary bodies to follow the motion of the Earth, hath a limited Sphere, out of which such a natural inclination would cease; besides that, as I have said, the Air is not that which carrieth the moveables along with it; which being separated from the Earth, do follow its motion; so that all the objections come to nothing, which this Author produceth to prove, that the Air cannot cause such effects.

SIMP. To shew therefore, that that cannot be, it will be necessary to say, that such like effects depend on an interne principle, against which position, *oboriuntur difficillima, immo inextricabiles quaestiones secundae*, of which sort are these that follow. *Principium illud internum vel est accidens, vel substantia. Si primum; quale nam illud? nam qualitas locomotiva circum, hactenus nulla*

The propension of elementary bodies to follow the Earth, hath a limited Sphere of activity.

videtur agnita. (In English thus:) Contrary to which position there do arise most difficult, yea inextricable second questions, such as these; That intern principle is either an accident, or a substance: If the first; what manner of accident is it? For a locomotive quality about the centre, seemeth to be hitherto acknowledged by none.

SALV. How, is there no such thing acknowledged? Is it not known to us, that all these elementary matters move round, together with the Earth? You see how this Author supposeth for true, that which is in question.

SIMP. He saith, that we do not see the same; and me thinks, he hath therein reason on his side.

SALV. We see it not, because we turn round together with them.

SIMP. Hear his other Argument. *Quæ etiam si esset, quomodo tamen inveniretur in rebus tam contrariis? in igne, ut in aquâ; in aëre, ut in terrâ; in viventibus, ut in animâ carentibus?* [In English thus:] Which although it were, yet how could it be found in things so contrary? in the fire, as in the water? in the air, as in the earth? in living creatures, as in things wanting life?

SALV. Supposing for this time, that water and fire are contraries; as also the air and earth; (of which yet much may be said) the most that could follow from thence would be, that those motions cannot be common to them, that are contrary to one another: so that v. g. the motion upwards, which naturally agreeth to fire, cannot agree to water; but that, like as it is by nature contrary to fire: so, to it that motion suiteth, which is contrary to the motion of fire, which shall be the motion *deorsum*; but the circular motion, which is not contrary either to the motion *sursum*, or to the motion *deorsum*, but may mix with both, as Aristotle himself affirmeth, why may it not equally suit with grave bodies and with light? The motions in the next place, which cannot be common to things alive; and dead, are those which depend on the soul: but those which belong to the body, in as much as it is elementary, and consequently participateth of the qualities of the elements, why may not they be common as well to the dead corps, as to the living body? And therefore, if the circular motion be proper to the elements, it ought to be common to the mixt bodies also.

SAGR. It must needs be, that this Author holdeth, that a dead cat, falling from a window, it is not possible that a live cat also could fall; it not being a thing convenient, that a carcase should partake of the qualities which suit with things alive.

SALV. Therefore the discourse of this Author concludeth nothing

nothing against one that should affirm, that the principle of the circular motions of grave and light bodies is an intern accident : I know not how he may prove, that it cannot be a substance.

SIMP. He brings many Arguments against this. The first of which is in these words : *Si secundum (nempe, si dicas tale principium esse substantiam) illud est aut materia, aut forma, aut compositum. Sed repugnant iterum tot diversae rerum naturae, quales sunt aves, limaces, saxa, sagittae, nives, fumi, grandines, pisces, &c. quae tamen omnia specie & genere differentia, moverentur à naturâ suâ circulariter, ipsa naturis diversissima, &c.* [In English thus] If the second, (that is, if you shall say that this principle is a substance) it is either matter, or form, or a compound of both. But such diverse natures of things are again repugnant, such as are birds, snails, stones, darts, snows, smoaks, hails, fishes, &c. all which notwithstanding their differences in species and kind, are moved of their own nature circularly, they being of their natures most different, &c.

SALV. If these things before named are of diverse natures, and things of diverse natures cannot have a motion in common, it must follow, if you would give satisfaction to all, that you are to think of, more than two motions onely of upwards and downwards : and if there must be one for the arrows, another for the snails, another for the stones, and another for fishes; then are you to berlink your self of worms, topazes and mushrooms, which are not less different in nature from one another, than snow and hail.

SIMP. It seems that you make a jest of these Arguments.

SALV. No indeed, *Simplicius*, but it hath been already answered above, to wit, that if one motion, whether downwards or upwards, can agree with all those things afore named, a circular motion may no less agree with them : and as you are a *Peripatetic*, do not you put a greater difference between an elementary comet and a celestial star, than between a fish and a bird ? and yet both those move circularly. Now propose your second Argument.

SIMP. *Si terra staret per voluntatem Dei, rotarentur cetera, an non ? si hoc, falsum est à naturâ gyrare ; si illud, redeunt priores quaestiones. Es sanè mirum esset, quòd Gavia pisciculo, Alauda nidulo suo, & corvus limaci, petraque, etiam volans, imminere non posset.* [Which I thus render:] If the Earth be supposed to stand still by the will of God, should the rest of bodies turn round or no ? If not, then it's false that they are revolved by nature ; if the other, the former questions will return upon us. And truly it would be strange that the Sea-pie should not be able to hover over the small fish, the Lark over her nest, and the Crow over the snail and rock, though flying.

SALV.

SALV. I would answer for my self in general terms, that if it were appointed by the will of God, that the Earth should cease from its diurnal revolution, those birds would do what ever should please the same Divine will. But if this Author desire a more particular answer, I should tell him, that they would do quite contrary to what they do now, if whilst they, being separated from the Earth, do bear themselves up in the air, the Terrestrial Globe by the will of God, should all on a sudden be put upon a precipitate motion; it concerneth this Author now to ascertain us what would in this case succeed.

SAGR. I pray you, *Salvatus*, at my request to grant to this Author, that the Earth standing still by the will of God, the other things, separated from it, would continue to turn round of their own natural motion, and let us hear what impossibilities or inconveniences would follow: for I, as to my own particulars, do not see how there can be greater disorders, than these produced by the Author himself, that is, that Larks, though they should fly, could not be able to hover over their nests, nor Crows over snails, or rocks: from whence would follow, that Crows must suffer for want of snails, and young Larks must die of hunger, and cold, not being able to be fed or sheltered by the wings of the old ones. This is all the ruine that I can conceive would follow, supposing the Authors speech to be true. Do you see, *Simplicius*, if greater inconveniences would happen?

SIMP. I know not how to discover greater; but it is very credible, that the Author besides these, discovered other disorders in Nature, which perhaps in reverend respect of her, he was not willing to instance in. Therefore let us proceed to the third Objection. *Insuper quæ sit, ut istæ res tam variæ tantum moveantur ab Occasu in Ortum, parallelæ ad Æquatorem? ut semper moveantur, nunquam quiescant?* [which speaks to this sense:] Moreover, how comes it to pass that these things, so diverse, are onely moved from the West towards the East, parallel to the Æquinoctial? that they always move, and never rest?

SALV. They move from West to East parallel to the Æquinoctial without ceasing, in the same manner as you believe the fixed stars to move from East to West, parallel to the Æquinoctial, without ever resting.

SIMP. *Quare, quod sunt altiores, celerius; quod humiliores, tardius?* (I. e.) Why are the higher the swifter, and the lower the slower?

SALV. Because that in a Sphere or circle, that turns about upon its own centre, the remoter parts describe greater circuits, and the parts nearer at hand describe lesser in the same time.

SIMP. *Quare, quæ Æquinoctiali proprio, in majori; quæ remotiores,*

remotiores, in minori circulo feruntur? [scilicet:] Why are those near the Equinoctial carried about in a greater circle; and those which are remote in a lesser?

SALV. To imitate the starry Sphere, in which those nearest to the Equinoctial, move in greater circles, than the more remote.

SIMP. Quare Pila eadem sub Equinoctiali tota circa centrum tertæ, ambitu maximo, celeritate incredibili; sub Polo verò circa centrum proprium, gyro nullo, tarditate supremâ volveretur? [That is:] Why is the same ball under the Equinoctial wholly turned round the centre of the Earth in the greatest circumference, with an incredible celerity; but under the Pole about its own centre, in no circuite, but with the ultimate degree of tardity?

SALV. To imitate the stars of the Firmament, that would do the like if they had the diurnal motion.

SIMP. Quare eadem res, pila v. g. plumbea, si semel terram circumvixit, descripto circulo maximo, eandem ubique non circummigrat secundum circulum maximum, sed translata extra Equinoctialem in circulis minoribus agetur? [Which speaketh thus:] Why doth not the same thing, as for example, a ball of lead turn round every where according to the same great circle, if once describing a great circle, it hath encompassed the Earth, but being removed from the Equinoctial, doth move in lesser circles?

SALV. Because so would, nay, according to the doctrine of Ptolomey, so have some fixed stars done, which once were very near the Equinoctial, and described very vast circles, and now that they are farther off, describe lesser.

SAGR. If I could now but keep in mind all these fine notions, I should think that I had made a great purchase; I must needs intreat you, *Simplicius*, to lend me this Book, for there cannot chuse but be a sea of rare and ingenious matters contained in it.

SIMP. I will present you with it.

SAGR. Not so, Sir; I would not deprive you of it; but are the Queries yet at an end?

SIMP. No Sir; hearken therefore. Si latio circularis gravibus & levibus est naturalis, qualis est ea quæ fit secundum lineam rectam? Nam si naturalis, quomodo & is motus qui circum est, naturalis est, cum specie differat à recto? Si violentus, qui fit, ut missile ignitum sursum evolans scintillosum caput sursum à terrâ, non autem circum volvetur, &c. [Which take in our idiom:] If a circular lation is natural to heavy and light things, what is that which is made according to a right line? For if it be natural, how then is that motion which is about the centre natural; seeing it differs

E c

differs

Of the mix: motion we see not the part that is circular, because we partake thereof.

differs in species from a right motion? If it be violent, how is it that a fiery dart flying upwards, sparkling over our heads at a distance from the Earth, but not turning about, &c.

SALV. It hath been said already very often, that the circular motion is natural to the whole, and to its parts, whilst they are in perfect disposure, and the right is to reduce to order the parts disordered; though indeed it is better to say, that neither the parts ordered or disordered ever move with a right motion, but with one mixed, which might as well be averred meerly circular; but to us but one part onely of this motion is visible and observable, that is, the part of the right, the other part of the circular being imperceptible to us, because we partake thereof. And this answers to the rays which move upwards, and round about, but we cannot distinguish their circular motion, for that, with that we ourselves move also. But I believe that this Author never thought of this mixture; for you may see that he resolutely saith, that the rays go directly upwards, and not at all in gyration.

SIMP. *Quare centrum sphere delapsa sub Equatore spiram describit in ejus plano: sub aliis parallelis spiram describit in cono? sub Polo descendit in axe lineam gyralem, decurrens in superficie cylindrica congnatam?* (In English to this purpose;) Why doth the centre of a falling Globe under the Equinoctial describe a spiral line in the plane of the Equator; and in other parallels a spiral about a Cone; and under the Pole descend in the axis describing a gyral line, running in a Cylindrical Superficie?

SALV. Because of the lines drawn from the Centre to the circumference of the sphere, which are those by which *graves* descend: that which terminates in the Equinoctial designeth a circle; and those that terminate in other parallels describe conical superficies; now the axis describeth nothing at all, but continueth in its own being. And if I may give you my judgment freely, I will say, that I cannot draw from all these Queries, any sense that interfereth with the motion of the Earth; for if I demand of this Author, (granting him that the Earth doth not move) what would follow in all these particulars, supposing that it do move, as *Copernicus* will have it; I am very confident, that he would say that all these effects would happen, that he hath objected, as inconveniences to disprove its mobility: so that in this mans opinion necessary consequences are accounted absurdities: but I beseech you, if there be any more, dispatch them, and free us speedily from this wearisome task.

SIMP. In this which follows he opposes *Copernicus* & his Sectators, who affirm, that the motion of the parts separated from their whole, is onely to unite themselves to their whole; but that the moving circularly

circularly along with the vertigenous diurnal revolution is absolutely natural : against which he objecteth, saying, that according to these mens opinion; *Si tota terra, una cum aqua in nihilum redigeretur, nulla grando aut pluvia è nube decideret, sed naturaliter tantum circumferetur, neque ignis ullus, aut igneum ascenderet, cum illorum non improbabili sententiâ ignis nullus sit supra.* [Which I translate to this sense:] If the whole Earth, together with the Water were reduced into nothing, no hail or rain would fall from the clouds, but would be onely naturally carried round; neither any fire or fiery thing would ascend, seeing to these that men it is no improbable opinion that there is no fire above.

SALV. The providence of this Philosopher is admirable, and worthy of great applause; for he is not content to provide for things that might happen, the course of Nature continuing, but will shew his care in what may follow from those things that he very well knows shall never come to pass. I will grant him therefore, (that I may get som pretty passages out of him) that if the Earth and Water should be reduced to nothing, there would be no more hails or rains, nor would igneal matters ascend any longer upwards, but would continually turn round: what will follow? what will the Philosopher say then?

SIMP. The objection is in the words which immediately follow; here they are: *Quibus tamen experientia & ratio adversatur.* Which nevertheless (saith he) is contrary to experience and reason.

SALV. Now I must yield, seeing he hath so great an advantage of me as experience, of which I am unprovided. For as yet I never had the fortune to see the Terrestrial Globe and the element of Water turn'd to nothing, so as to have been able to observe what the hail and water did in that little Chaos. But he perhaps tells us for our instruction what they did.

SIMP. No, he doth not.

SALV. I would give any thing to change a word or two with this person, to ask him, whether when this Globe vanished, it carried away with it the common centre of gravity, as I believe it did; in which case, I think that the hail and water would remain insensate and stupid amongst the clouds, without knowing what to do with themselves. It might be also, that attracted by that great void *Vacuum*, left by the Earths absenting, all the ambients would be rarified, and particularly, the air, which is extreme easily drawn, and would run thither with very great haste to fill it up. And perhaps the more solid and material bodies, as birds, (for there would in all probability be many of them scattered up and down in the air) would retire more towards the centre of the great vacant sphere; (for it seemeth very reasonable, that substances that

E c 2

under

under small bulk contain much matter, should have narrower places assigned them, leaving the more spacious to the more rarified) and there being dead of hunger, and resolved into Earth, would form a new little Globe, with that little water, which at that time was among the clouds. It might be also, that those matters as not beholding the light, would not perceive the Earths departure, but like blind things, would descend according to their usual custom to the centre, whither they would now go, if that globe did not hinder them. And lastly, that I may give this Philosopher a less irresolute answer, I do tell him, that I know as much of what would follow upon the annihilation of the Terrestrial Globe, as he would have done that was to have followed in and about the same, before it was created. And because I am certain he will say, that he would never have been able to have known any of all those things which experience alone hath made him knowing in, he ought not to deny me pardon, and to excuse me if I know not that which he knows, touching what would ensue upon the annihilation of the said Globe: for that I want that experience which he hath. Let us hear if he have any thing else to say.

SIMP. There remains this figure, which represents the Terrestrial Globe with a great cavity about its centre, full of air; and to shew that *Graves* move not downwards to unite with the Terrestrial Globe, as *Copernicus* saith, he constituteth this stone in the centre; and demandeth, it being left at liberty, what it would do; and he placeth another in the space of this great vacuum, and asketh the same question. Saying, as to the first: *Lapis in centro constitutus, aut ascendet ad terram in punctum aliquod, aut non. Si secundum; falsum est, partes ob solam sejunctionem à toto, ad illud moveri. Si primum; omnis ratio & experientia renititur, neque gravia in sua gravitatis centro conquiescent. Item si suspensus lapis, liberatus decidat in centrum, separabit se à toto, contra Copernicum: si pendeat, refragatur omnis experientia, cum videamus integras fornices corruere.* (Wherein he saith:) The stone placed in the centre, either ascendeth to the Earth in some point, or no. If the second, it is false that the parts separated from the whole, move unto it. If the first; it contradiceth all reason and experience, nor doth the grave body rest in the centre of its gravity. And if the stone being suspended in the air, be let go, do descend to the centre, it will separate from its vvhole, contrary to *Copernicus*: if it do hang in the air, it contradiceth all experience: since we see whole Vaults to fall down.

SALV. I vwill answer, though vvith great disadvantage to my self, seeing I have to do vvith one vvho hath seen by experience, vvhat these stones do in this great Cave: a thing, vvwhich for my part I have not seen; and vvill say, that things grave have an existence

stence before the common centre of gravity : so that it is not one centre alone, which is no other than indivisible point, and therefore of no efficacy, that can attract unto it grave matters ; but that those matters conspiring naturally to unite, form to themselves a common centre, which is that about which parts of equal moment consist : so that I hold, that if the great aggregate of grave bodies were gathered all into any one place, the small parts that were separated from their whole, would follow the same, and if they were not hindered, would penetrate wherever they should find parts less grave than themselves : but coming where they should meet with matters more grave, they would descend no farther. And therefore I hold, that in the Cave full of air, the whole Vault would press, and violently rest it self onely upon that air, in case its hardness could not be overcome and broken by its gravity ; but loose stones, I believe, would descend to the centre, and not swim above in the air : nor may it be said, that they move not to their whole, though they move whither all the parts of the whole would transfer themselves, if all impediments were removed.

Things grave are before the centre of gravity.

The great mass of grave bodies being transferred out of their place, the separated parts would follow that mass.

SIMP. That which remaineth, is a certain Errour which he observeth in a Disciple of *Copernicus*, who making the Earth to move with an annual motion, and a diurnal, in the same manner as the Cart-wheel moveth upon the circle of the Earth, and in it self, did constitute the Terrestrial Globe too great, or the great Orb too little ; for that 365 revolutions of the *Æquinoctial*, are less by far than the circumference of the great Orb.

SALV. Take notice that you mistake, and tell us the direct contrary to what must needs be written in that Book ; for you should say, that that same *Copernican* Author did constitute the Terrestrial Globe too little, and the great Orb too big ; and not the Terrestrial Globe too big, and the annual too little.

SIMP. The mistake is not mine ; see here the words of the Book. *Non videt, quod vel circulum annuum æquo minorem, vel orbem terreum justo multò fabricet majorem.* (In English thus :) He seeth not, that he either maketh the annual circle equal to the less, or the Terrestrial Orb much too big.

SALV. I cannot tell whether the first Author erred or no, since the Author of this Treatise doth not name him ; but the error of this Book is certain and unpardonable, whether that follower of *Copernicus* erred or not erred ; for that your Author passeth by so material an error, without either detecting or correcting it. But let him be forgiven this fault, as an error rather of inadvertencie, than of any thing else : Farthermore, were it not, that I am already wearied and tired with talking and spending so much time with very little profit, in these frivolous janglings and altercations, I could shew, that it is not impossible for a circle, though

no

It is not impossible with the circumference of a small circle few times revolved to measure and describe a line bigger than any great circle whatsoever.

no bigger than a Cart-wheel, with making not 365, but lesse than 20 revolutions, to describe and measure the circumference, not onely of the grand Orb, but of one a thousand times greater; and this I say to shew, that there do not want far greater subtilties, than this wherewith your Author goeth about to detect the errour of *Copernicus*: but I pray you, let us breathe a little, that so we may proceed to the other Philosopher, that opposeth of the same *Copernicus*.

SAGR. To confesse the truth, I stand as much in need of respite as either of you; though I have onely wearied my eares; and were it not that I hope to hear more ingenious things from this other Author, I question whether I should not go my ways, to take the air in my * Pleasure-boat.

SIMP. I believe that you will hear things of greater moment; for this is a most accomplished Philosopher, and a great Mathematician, and hath confuted *Tycho* in the businesse of the Comets, and new Stars.

* The name of the Author is *Scipio Claramontius*.

SALV. Perhaps he is the same with the Author of the Book, called *Anti-Tycho*?

SIMP. He is the very same: but the confutation of the new Stars is not in his *Anti-Tycho*, onely so far as he proveth, that they were not prejudicial to the inalterability and ingenerability of the Heavens, as I told you before; but after he had published his *Anti-Tycho*, having found out, by help of the Parallaxes, a way to demonstrate, that they also are things elementary, and contained within the concave of the Moon, he hath writ this other Book, *de tribus novis Stellis, &c.* and therein also inserted the Arguments against *Copernicus*: I have already shewn you what he hath written touching these new Stars in his *Anti-Tycho*, where he denied not, but that they were in the Heavens; but he proved, that their production altered not the inalterability of the Heavens, and that he did, with a Discourse purely philosophical, in the same manner as you have already heard. And I then forgot to tell you, how that he afterwards did finde out a way to remove them out of the Heavens; for he proceeding in this confutation, by way of computations and parallaxes, matters little or nothing at all understood by me, I did not mention them to you, but have bent all my studies upon these arguments against the motion of the Earth, which are purely natural.

SALV. I understand you very well: and it will be convenient after we have heard what he hath to say against *Copernicus*, that we hear, or see at least the manner wherewith he, by way of Parallaxes, proveth those new stars to be elementary, which so many famous Astronomers constitute to be all very high, and amongst the stars of the Firmament; and as this Author accomplisheth such
an

an enterprize of pulling the new stars out of heaven, and placing them in the elementary Sphere, he shall be worthy to be highly exalted, and transferred himself amongst the stars, or at least, that his name be by fame eternized amongst them. Yet before we enter upon this, let us hear what he alledgerh against the opinion of *Copernicus*, and do you begin to recite his Arguments.

SIMP. It will not be necessary that we read them *ad verbum*, because they are very prolix; but I, as you may see, in reading them several times attentively, have marked in the margine those words, wherein the strength of his arguments lie, and it will suffice to read them. The first Argument beginneth here. *Et primo, si opinio Copernici recipiatur, Criterium naturalis Philosophiae, ni prorsus tollatur, vehementer saltem labefactari videtur.* [In our Idiom thus] And first, if *Copernicus* his opinion be embraced, the *Criterium* of natural Philosophy will be, if not wholly subverted, yet at least extreemly shaken.

The opinion of
Copernicus over-
throws the Crite-
rium of Philosophy

Which, according to the opinion of all the sects of Philosophers requirerh, that Sense and Experience be our guides in philosophizing: But in the *Copernican* position the Senses are greatly deluded, whilst that they visibly discover neer at hand in a pure *Medium*, the gravest bodies to descend perpendicularly downwards, never deviating a single hairs breadth from rectitude; and yet according to the opinion of *Copernicus*, the sight in so manifest a thing is deceived, and that motion is not reall straight, but mixt of right and circular.

SALV. This is the first argument, that *Aristotle*, *Ptolomy*, and all their followers do produce; to vvhich we have abundantly answered, and shewn the Paralogisme, and with sufficient plainnesse proved, that the motion in common to us and other moveables, is, as if there were no such thing; but because true conclusions meet with a thousand accidents, that confirme them, I vwill, with the favour of this Philosopher, adde something more; and you *Simplicius* personating him, answer me to vvhath I shall ask you: And first tell me, vvhath effect hath that stone upon you, which falling from the top of the Tower, is the cause that you perceive that motion; for if its fall doth operate upon you neither more nor lesse, than its standing still on the Towers top, you doubtlesse could not discern its descent, or distinguish its moving from its lying still.

Common motion
is, as if it never
were.

The argument
taken from things
falling perpendicu-
larly, another way
confuted.

SIMP. I comprehend its moving, in relation to the Tower, for that I see it one while just against such a mark in the said Tower, and another while against another lower, and so successively, till that at last I perceive it arrived at the ground.

SALV. Then if that stone were let fall from the tallons of an Eagle flying, and should descend thorow the simple invisible Air,

and

and you had no other object visible and stable, wherewith to make comparisons to that, you could not perceive its motion?

Whence the motion of a cadent body is collected.

SIMP. No, nor the stone it self; for if I would see it, when it is at the highest, I must raise up my head, and as it descendeth, I must hold it lower and lower, and in a word, must continually move either that, or my eyes, following the motion of the said stone.

The motion of the eye argueth the motion of the object looked on.

SALV. You have nowv rightly answered: you know then that the stone lyeth still, when without moving your eye, you alwayes see it before you; and you know that it moveth, when for the keeping it in sight, you must move the organ of sight, the eye. So then when ever without moving your eye, you continually behold an object in the self same aspect, you do alwayes judge it immovable.

SIMP. I think it must needs be so.

SALV. Nowv fancy your self to be in a ship, and to have fixed your eye on the point of the Sail-yard: Do you think, that because the ship moveth very fast, you must move your eyes to keep your sight alwayes upon the point of the Sail-yard, and to follow its motion?

SIMP. I am certain, that I should need to make no change at all, and that not only in the sight; but if I had aimed a Musket at it, I should never have need, let the ship move how it wvill, to stir it an hairs breadth to keep it full upon the same.

SALV. And this happens because the motions which the Ship conferreth on the Sail-yard, it conferreth also upon you, and upon your eyes; so that you need not stir it a jot to behold the top of the Sail-yard: and consequently, it wvill seem to you immovable. Now this Discourte being applied to the revolution of the Earth, and to the stone placed in the top of the Tower, in which you cannot discern any motion, because that you have that motion which is necessary for the following of it, in common with it from the Earth; so that you need not move your eye. When again there is conferred upon it the motion of descent, which is its particular motion, and not yours, and that it is intermixed with the circular, that part of the circular which is common to the stone, and to the eye, continueth to be imperceptible, and the right one ly is perceived, for that to the perception of it, you must follow it with your eye, looking lower and lower. I wish for the undeceiving of this Philosopher, that I could advise him, that some time or other going by water, he would carry along with him a Vessel of reasonable depth full of water, and prepare a ball of wax, or other matter that would descend very slowly to the bottome, so that in a minute of an hour, it would scarce sink a yard; and that rowing the boat as fast as could be, so that in a minute of an hour it

An experiment that sheweth how the common motion is imperceptible.

it should run above an hundred yards, he would let the ball submerge into the water, & freely descend, & diligently observe its motion. If he would but do thus, he should see, first, that it would go in a direct line towards that point of the bottom of the vessel, whither it would tend, if the boat should stand still; & to his eye, and in relation to the vessel, that motion would appear most straight and perpendicular, and yet he could not say, but that it would be composed of the right motion downwards, and of the circular about the element of water. And if these things befall in matters not natural, and in things that we may experiment in their state of rest; & then again in the contrary state of motion, and yet as to appearance no diversity at all is discovered, & that they seem to deceive our sense what can we distinguish touching the Earth, which hath been perpetually in the same constitution, as to motion and rest? And in what time can we experiment whether any difference is discernable amongst these accidents of local motion, in its diverse states of motion and rest, if it eternally indureth in but one onely of them?

SAGR. These Discourses have somewhat whetted my stomach, which those fishes, and snails had in part nauseated; and the former made me call to minde the correction of an error, that hath so much appearance of truth, that I know not whether one of a thousand would refuse to admit it as unquestionable. And it was this, that sailing into Syria, and carrying with me a very good Telescope, that had been bestowed on me by our Common Friend, who not many dayes before had invented, I proposed to the Mariners, that it would be of great benefit in Navigation to make use of it upon the round top of a ship, to discover and kenne Vessels afar off. The benefit was approved, but there was objected the difficulty of using it, by reason of the Ships continual fluctuation; and especially on the round top, where the agitation is so much greater, and that it would be better for any one that would make use thereof to stand at the Partners upon the upper Deck, where the tossing is lesse than in any other place of the Ship. I (for I will not conceal my error) concurred in the same opinion, and for that time said no more: nor can I tell you by what hints I was moved to return to ruminate with my self upon this businesse, and in the end came to discover my simplicity (although excusable) in admitting that for true, which is most false; false I say, that the great agitation of the basket or round top, in comparison of the small one below, at the partners of the Mast, should render the use of the Telescope more difficult in finding out the object.

An ingenious consideration about the possibility of using the Telescope with as much facility on the round top of the Mast of a ship, as on the Deck.

SALV. I should have accompanied the Mariners, and your self at the beginning.

SIMP. And so should I have done, and still do: nor can I believe, if I should think of it an hundred years, that I could understand it otherwise.

FF

SAGR.

SAGR. I may then, it seems, for once prove a Master to you both. And because the proceeding by interrogatories doth in my opinion much dilucidate things, besides the pleasure which it affords of confounding our companion, forcing from him that which he thought he knew not, I will make use of that artifice. And first, I suppose that the Ship, Gally, or other Vessel, which we would discover, is a great way off; that is, four, six, ten, or twenty * miles, for that to kenne those neerer at hand there is no need of these Glasses: & consequently, the Telescope may at such a distance of four or six miles conveniently discover the whole Vessel, & a much greater built. Now I demand what for species, & how many for number are the motions that are made upon the round top, depending on the fluctuation of the Ship.

SALV. We will suppose that the Ship goeth towards the East. First, in a calme Sea, it would have no other motion than this of progression, but adding the undulation of the Waves, there shall result thence one, which alternately hoysing and lowering the poop and prow, maketh the round top, to lean forwards and backwards; other waves driving the vessel sideways, bow the Mast to the Starboard and Larboard; others, may bring the ship somewhat about, and bear her away by the Miske from East, one while towards the * Northeast, another while toward the South-east; others bearing her up by the Carine may make her onely to rise, and fall; and in sum, these motions are for species two, one that changeth the direction of the Telescope angularly, the other lineally, without changing angle, that is, alwayes keeping the tube of the Instrument parallel to its self.

SAGR. Tell me, in the next place, if we, having first directed the Telescope yonder away towards the Tower of * Burano, six miles from hence, do turn it angularly to the right hand, or to the left, or else upwards or downwards, but a * straws breadth, what effect shall it have upon us touching the finding out of the said tower?

SALV. It would make us immediately lose sight of it, for such a declination, though small here, may import there hundreds and thousands of yards.

SAGR. But if without changing the angle, keeping the tube alwayes parallel to it self, we should transfer it ten or twelve yards farther off to the right or left hand, upwards or downwards, what alteration would it make as to the Tower?

SALV. The change would be absolutely undiscernable; for that the spaces here and there being contained between parallel rayes, the mutations made here and there, ought to be equal, and because the space which the Instrument discovers yonder, is capable of many of those Towers; therefore we shall not lose sight of it.

SAGR. Returning now to the Ship, we may undoubtedly affirm, that the Telescope moving to the right or left, upwards, or down-

* I deviate here from the strict Sea Dialect, which denominates all distances by Leagues.

Different motions depending on the fluctuation of the Ship.

* Greco, which the Latine Translator according to his usual carelesse-ness (so call it no worse) translates *Corum Ventum*, the Northwest Wind; for *Ventum Libanotum*.

Two mutations made in the Telescope, depending on the agitation of the Ship.

* This is a Castle six Italian miles from Venice Northwards.

* *On nero d'ugna*, the black or paring of a nail.

downwards, and also forwards or backwards ten or fifteen fathom, keeping it all the while parallel to its self, the visive ray cannot stray from the point observed in the object, more than those fifteen fathom; and because in a distance of eight or ten miles, the Instrument takes in a much greater space than the Gally or other Vessel kenn'd; therefore that small mutation shall not make me lose sight of her. The impediment therefore, and the cause of losing the object cannot befall us, unlesse upon the mutation made angularly; since that *Telescopes* transportation higher or lower, to the right, or to the left, by the agitation of the ship, cannot import any great number of fathomes. Now suppose that you had two *Telescopes* fixed, one at the Partners close by the Deck, and the other at the round top, nay at the main top, or main top-gallant top, where you hang forth the *Pennon* or streamer, and that they be both directed to the Vessel that is ten miles off, tell me, whether you believe that any agitation of the ship, & inclination of the Mast, can make greater changes, as to the angle, in the higher tube, than in the lower? One wave arising, the prow will make the main top give back fifteen or twenty fathom more than the foot of the Mast, and it shall carry the upper tube along with it so great a space; & the lower it may be not a palm; but the angle shall change in one Instrument as well as in the other; and likewise a side-billow shall bear the higher tube an hundred times as far to the Larboard or Starboard, as it will the other below; but the angles change not at all, or else alter both alike. But the mutation to the right hand or left, forwards or backwards, upwards or downwards, bringeth no sensible impediment in the kenning of objects remote, though the alteration of the angle maketh great change therein; Therefore it must of necessity be confessed, that the use of the *Telescope* on the round top is no more difficult than upon the Deck at the Partners; seeing that the angular mutations are alike in both places.

SALV. How much circumspection is there to be used in affirming or denying a proposition? I say again, that hearing it resolutely affirmed, that there is a greater motion made on the Masts top, than at its partners, every one will perswade himself, that the use of the *Telescope* is much more difficult above than below. And thus also I will excuse those Philosophers, who grow impatient and fly out into passion against such as will not grant them, that that Cannon bullet which they cleerly see to fall in a right line perpendicularly, doth absolutely move in that manner; but will have its motion to be by an arch, and also very much inclined and transversal: but let us leave them in these labyrinths, and let us hear the other objections, that our Author in hand brings against *Copernicus*.

SIMP. The Author goeth on to demonstrate that in the Doctrine of *Copernicus*, it is requisite to deny the Senses; and the

The annual motion of the Earth must cause a perpetual and strong winde.

greatest Sensations, as for instance it would be, if we that feel the respirations of a gentle gale, should not feel the impulse of a perpetual winde that beateth upon us with a velocity that runs more than 2529 miles an hour, for so much is the space that the centre of the Earth in its annual motion passeth in an hour upon the circumference of the grand Orb, as he diligently calculates; and because, as he saith, by the judgment of *Copernicus*, *Cum terra movetur circumpositus aer, motus tamen ejus, velocior licet ac rapidior celerrimo quocunque vento, à nobis non sentiretur, sed summa tum tranquillitas reputaretur, nisi alius motus accederet. Quid est verò decipi sensum, nisi hæc esset deceptio?* [Which I make to speak to this sense.] The circumposed air is moved with the Earth, yet its motion, although more speedy and rapid than the swiftest wind whatsoever, would not be perceived by us, but then would be thought a great tranquillity, unlesse some other motion should happen; what then is the deception of the sense; if this be not?

The air always touching us with the same part of it cannot make us feel it.

SALV. It must needs be that this Philosopher thinketh, that that Earth which *Copernicus* maketh to turn round, together with the ambient air along the circumference of the great Orb, is not that whereon we inhabit, but some other separated from this; for that this of ours carrieth us also along with it with the same velocity, as also the circumjacent air: And what beating of the air can we feel when we fly vvith equal speed from that vvhich should accost us? This Gentleman forgot, that vve no less than the Earth and air are carried about, and that consequently vve are always touch'd by one and the same part of the air, vvhich yet doth not make us feel it.

SIMP. But I rather think that he did not so think; hear the vvords vvhich immediately follovv. *Præterea nos quoque rotamur ex circumductione terræ &c.*

SALV. Now I can no longer help nor excuse him; do you plead for him and bring him off, *Simplicius*.

SIMP. I cannot thus upon the sudden think of an excuse that pleaseth me.

SALV. Go to; take this whole night to think on it, and defend him to morrow; in the mean time let us hear some other of his objections.

He that will follow Copernicus, must deny his senses.

SIMP. He prosecuteth the same Objection, shewing, that in the way of *Copernicus*, a man must deny his own senses. For that this principle whereby we turn round with the Earth, either is intrinsic to us, or external; that is, a rapture of that Earth; and if it be this second, we not feeling any such rapture, it must be confessed that the sense of feeling, doth not feel its own object touching it, nor its impression on the sensible part: but if the principle

ciple be intrinsecal, we shall not perceive a local motion that is derived from our selves, and we shall never discover a propension perpetually annexed to our selves.

SALV. So that the instance of this Philosopher lays its stress upon this, that whether the principle by which we move round with the Earth be either extern, or intern, yet however we must perceive it, and not perceiving it, it is neither the one nor the other, and therefore we move not, nor consequently the Earth. Now I say, that it may be both ways, and yet we not perceive the same. And that it may be external, the experiment of the boat superabundantly satisfieth me; I say, superabundantly, because it being in our power at all times to make it move, and also to make it stand still, and with great exactness to make observation, whether by some diversity that may be comprehended by the sense of feeling, we can come to know whether it moveth or no, seeing that as yet no such science is obtained: Will it then be any matter of wonder, if the same accident is unknown to us on the Earth, the which may have carried us about perpetually, and we, without our being ever able to experiment its rest? You, *Simplicius*, as I believe, have gone by boat many times to *Padova*, and if you will confess the truth, you never felt in your self the participation of that motion, unless when the boat running a-ground, or encountering some obstacle, did stop, and that you with the other Passengers being taken on a sudden, were with danger over-set. It would be necessary that the Terrestrial Globe should meet with some rub that might arrest it, for I assure you, that then you would discern the impulse residing in you, when it should toss you up towards the Stars. It's true, that by the other senses, but yet assisted by Reason, you may perceive the motion of the boat, that is, with the sight, in that you see the trees and buildings placed on the shoar, which being separated from the boat, seem to move the contrary way. But if you would by such an experiment receive intire satisfaction in this business of the Terrestrial motion, look on the stars, which upon this reason seem to move the contrary way. As to the wondering that we should not feel such a principle, supposing it to be internal, is a less reasonable conceit; for if we do not feel such a one, that cometh to us from without, and that frequently goeth away, with what reason can we expect to feel it, if it immutably and continually resides in us? Now let us see what you have farther to allege on this argument.

SIMP. Take this short exclamation. *Ex hac itaque opinione necesse est diffidere nostris sensibus, ut penitus fallacibus vel stupidis in sensibus, etiam conjunctissimis, dijudicandis. Quam ergo veritatem sperare possumus à facultate adeò fallaci ortum trahentem?* [Which I render thus:] From this opinion likewise, we must of necessity

Our motion may be either interne or externe, and yet we never perceive or feel it.

The motion of a Boat insensible to those that are with in it, as to the sense of feeling.

The boats motion is perceptible to the sight join'd with reason.

The terrestrial motion collected from the stars.

necessity suspect our own senses, as wholly fallible, or stupid in judging of sensible things even very near at hand. What truth therefore can we hope for, to be derived from so deceiveable a faculty?

SALV. But I desire not to deduce precepts more profitable, or more certain, learning to be more circumspect and less confident about that which at first blush is represented to us by the senses, which may easily deceive us. And I would not have this Author trouble himself in attempting to make us comprehend by sense, that this motion of descending Graves is simply right; and of no other kind; nor let him exclaim that a thing so clear, manifest, and obvious should be brought in question; for in so doing, he maketh others believe, that he thinketh those that deny that motion to be absolutely streight, but rather circular, the stone did sensibly see it to move in an arch, seeing that he inviteth their senses more than their Reason, to judg of that effect: which is not true, *Simplicius*, for like as I, that am indifferent in all these opinions, and onely in the manner of a Comedian, personate *Copernicus* in these our representations, have never seen, nor thought that I have seen that stone fall otherwise than perpendicularly, so I believe, that to the eyes of all others it seemed to do the same. Better it is therefore, that deposing that appearance in which all agree, we make use of our Reason, either to confirm the reality of that, or to discover its fallacy.

SAGR. If I could any time meet with this Philosopher, who yet me thinks is more sublime than the rest of the followers of the same doctrines, I would in token of my affection put him in mind of an accident which he hath doubtless very often beheld; from which, with great conformity to that which we now discourse of, it may be collected how easily one may be deceived by the bare appearance, or, if you will, representation of the sense. And the accident is, the Moons seeming to follow those that walk the streets in the night, with a pace equal to theirs, whilst they see it go gliding along the Roofs of houses, upon which it sheweth just like a cat, that really running along the ridges of houses, leaveth them behind. An appearance that, did not reason interpose, would but too manifestly delude the sight.

Arguments against the Earths motion taken, ex rerum natura.

Three Axioms that are supposed manifest.

SIMP. Indeed there want not experiments that render us certain of the fallacy of the meer senses; therefore suspending such sensations for the present, let us hear the Arguments that follow which are taken, as he saith, *ex rerum natura*. The first of which is, that the Earth cannot of its own nature move with three motions very different; or otherwise we must deny many manifest Axioms. The first whereof is, that *Omnis effectus dependeat ab aliquâ causâ*; [*i. e.*] that every effect dependeth on some cause.

The

A fourth Axiome against the motion of the Earth

Flexures necessary in animals for the diversity of their motions.

Another argument against the threefold motion of the Earth.

The Flexures in animals are not made for the diversity of motions.

The motions of animals are of one sort.

The ends of the bones are all round.

It is demonstrated, that the ends of the bones are of necessity to be round.

makes the objection, yea, it is totally overthrown by that which immediately after he addeth for a greater confirmation of his argument, as you shall hear. He re-inforceth his argument; I say, with another Axiome, which is this; That *natura in rebus necessariis nec deficiat, nec abundat*: i.e. That nature in things necessary is neither defective, nor superfluous. This is obvious to the observers of natural things, and chiefly of animals, in which, because they are to move with many motions; Nature hath made many flexures, and hath thereunto commodiously knitted the parts for motion; as to the knees, to the hips; for the inabling of living creatures to go, and run at their pleasure. Moreover in man he hath framed many flexions, and joynts, in the elbow, and hand, to enable them to perform many motions. From these things the argument is taken against the threefold motion of the Earth. [Either the Body, that is one, and continue, without any manner of knittings or flexions; can exercise divers motions, or cannot: If it can without them; then in vain hath nature framed the flexures in animals; which is contrary to the Axiome: but if it cannot without them; then the Earth, one body, and continue, and deprived of flexures, and joynts; cannot of its own nature move with plurality of motions.] You see now how craftily he falls upon your answer, as if he had foreseen it.

SALV. Are you serious, or do you jest?

SIMP. I speak it with the best judgment I have.

SALV. You must therefore see that you have as fortunate an hand in defending the reply of this Philosopher, against some other rejoinders made to him; therefore answer for him, I pray you, seeing we cannot have him here. You first admit it for true, that Nature hath made the joynts, flexures, and knuckles of living creatures, to the intent that they might move with sundry and divers motions; and I deny this proposition; and say, that these flexions are made, that the animal may move one, or more of its parts, the rest remaining immoved: and I say, that as to the species and differences of motions those are of one kind alone, to wit, all circular, and for this cause you see all the ends of the moveable bones to be convex or concave, and of these some are spherical, as are those that are to move every way, as in the shoulderjoynt, the arme of the Ensigne doth, in displaying the Colours, and that of the Falconer in bringing his Hawk to the lure; and such is the flexure of the elbow, upon which the hand turns round, in boring with an augure: others are circular onely one way, and as it were cylindrical, which serve for the members that bend onely in one fashion, as the joynts of the fingers one above another, &c. But without more particular inductions, one only general discourse may make this truth understood; and this is, that of a solid body

body that moveth, one of its extreame standing still without changing place, the motion must needs be circular, and no other: and because in the living creatures moving, one of its members doth not separate from the other its conterminal, therefore that motion is of necessity circular.

SIMP. How can this be? For I see the animal move with an hundred motions that are not circular, and very different from one another, as to run, to skip, to climb, to descend, to swim, and many others.

SALV. Tis well: but these are secondary motions, depending on the preceding motions of the joynts and flexures. Upon the plying of the legs to the knees, and the thighs to the hips, which are circular motions of the parts, is produced, as consequents, the skip, or running, which are motions of the whole body, and these may possibly not be circular. Now because one part of the terrestrial Globe is not required to move upon another part immoveable, but that the motion is to be of the whole body, there is no need in it of flexures.

SIMP. This (will the adversary rejoyn) might be, if the motion were but one alone, but they being three, and those very different from each other, it is not possible that they should concur in an * articulate body.

SALV. I verily believe that this would be the answer of the Philosopher. Against which I make opposition another way; and ask you, whether you think that by way of joynts and flexures one may adapt the terrestrial Globe to the participation of three different circular motions? Do you not answer me? Seeing you are speechlesse, I will undertake to answer for the Philosopher, who would absolutely reply that they might; for that otherwise it would have been superfluous, and besides the purpose to have proposed to consideration, that nature maketh the flexions, to the end, the moveable may move with different motions; and that therefore the terrestrial Globe having no flexures, it cannot have those three motions which are ascribed to it. For if he had thought, that neither by help of flexures, it could be rendered apt for such motions, he would have freely affirmed, that the Globe could not move with three motions. Now granting this, I intreat you, and by you, if it were possible, that Philosopher, Author of the Argument, to be so courteous as to teach me in what manner those flexures should be accommodated, so that those three motions might commodiously be exercised; and I grant you four or six months time to think of an answer. As to me, it seemeth that one principle onely may cause a plurality of motions in the Terrestrial Globe, just in the same manner that, as I told you before, one onely principle with the help of various instruments

G g pro-

The motion of animals are all circular.

Secondary motions of animals dependent on the first

The Terrestrial Globe hath no need of flexures.

* Without joynts

It is desired to know, by means of what flexures and joynts the Terrestrial Globe might move with three diverse motions.

One only principle may cause a plurality of motions in the Earth.

produceth sundry and divers motions in living creatures. And as to the flexures there is no need of them, the motions being of the whole; and not of some particular parts; and because they are to be circular, the meer spherical figure is the most perfect articulation or flexion that can be desired.

SIMP. The most that ought to be granted upon this, would be, that it may hold true in one single motion; but in three different motions; in my opinion, and that of the Author, it is impossible; as he going on, prosecuting the objection, writes in the following words. *Let us suppose, with Copernicus, that the Earth moveth of its own faculty, and upon an intrinsic principle from West to East in the plane of the Ecliptick; and again, that it also by an intrinsic principle revolveth about its centre, from East to West; and for a third motion, that it of its own inclination deflecteth from North to South, and so back again.* It being a continue body, and not knit together with joints and flexions, our fancy and our judgment will never be able to comprehend, that one and the same natural and indistinct principle, that is, that one and the same propension, should actuate it at the same instant with different, and as it were of contrary motions. I cannot believe that any one would say such a thing; unless he had undertook to maintain this position right or wrong.

*A grosse error
of the opposer of
Copernicus.*

SALV. Stay a little; and find me out this place in the Book. *Figamus modo cum Copernico, terram aliqua sua vi, & ab indito principio impelli ab Occasu ad Ortum in Eclipticæ plano; tum rursus revolvæ ab indito etiam principio, circa suum centrum, ab Ortum in Occasum; tertio deflecti rursus suapte nutu à septentrione in Austrum, & vicissim.* I had thought, *Simplicius*, that you might have erred in reciting the words of the Author; but now I see that he, and that very grossely, deceiveth himself; and to my grief, I find that he hath set himself to oppose a position, which he hath not well understood; for these are not the motions which Copernicus assigns to the Earth. Where doth he find that Copernicus maketh the annual motion by the Ecliptick contrary to the motion about its own centre? It must needs be that he never read his Book, which in an hundred places, and in the very first Chapters affirmeth those motions to be both towards the same parts, that is from West to East. But without others telling him, ought he not of himself to comprehend, that attributing to the Earth the motions that are taken, one of them from the Sun, and the other from the *primum mobile*, they must of necessity both move one and the same way.

*A subtil and
mortal simple ar-
gument against
Copernicus.*

SIMP. Take heed that you do not erre your self, and Copernicus also. The Diurnal motion of the *primum mobile*, is it not from East

East to West? And the annual motion of the Sun through the Ecliptick, is it not on the contrary from West to East? How then can you make these motions being conferred on the Earth, of contraries to become consistent?

SAGR. Certainly, *Simplicius* hath discovered to us the original cause of error of this Philosopher; and in all probability he would have said the very same.

SALV. Now if it be in our power, let us at least recover *Simplicius* from this error, who seeing the Stars in their rising to appear above the Oriental Horizon, will make it no difficult thing to understand, that in case that motion should not belong to the Stars, it would be necessary to confesse, that the Horizon, with a contrary motion would go down; and that consequently the Earth would revolve in it self a contrary way to that where-with the Stars seem to move, that is from West to East, which is according to the order of the Signes of the Zodiack. As, in the next place, to the other motion, the Sun being fixed in the centre of the Zodiack, and the Earth moveable about its circumference, to make the Sun seem unto us to move about the said Zodiack, according to the order of the Signes, it is necessary, that the Earth move according to the same order, to the end that the Sun may seem to us to possesse alwayes that degree in the Zodiack, that is opposite to the degree in which we find the Earth; and thus the Earth running, *verbi gratia*, through *Aries*, the Sun will appear to run thorow *Libra*; and the Earth passing thorow the signe *Taurus*, the Sun will passe thorow *Scorpio*, and so the Earth going thorow *Gemini*, the Sun seemeth to go thorow *Sagittarius*; but this is moving both the same way, that is according to the order of the signes; as also was the revolution of the Earth about its own centre.

SIMP. I understand you very well, and know not what to alledge in excuse of so grosse an error.

SALV. And yet, *Simplicius*, there is one yet worse then this; and it is, that he makes the Earth move by the diurnal motion about its own centre from East to West; and perceives not that if this were so, the motion of twenty four hours appropriated by him to the Universe, would, in our seeming, proceed from West to East; the quite contrary to that which we behold.

SIMP. Oh strange! Why I, that have scarce seen the first elements of the Sphere, would not, I am confident, have erred so horribly.

SALV. Judg now what pains this Antagonist may be thought to have taken in the Books of *Copernicus*, if he absolutely invert the sense of this grand and principal Hypothesis, upon which is founded the whole summe of those things wherein *Copernicus* dissenteth

The error of the Antagonist is manifest, by declaring that the annual and diurnal motions belonging to the Earth are both one way, and not contrary.

By another gross error it is seen that the Antagonist had but little studied Copernicus.

*It is questioned,
whether the oppo-
nent understood
the third motion
assigned to the
Earth by Coperni-
cus.*

dissenteth from the doctrine of *Aristotle* and *Ptolomy*. As again, to this third motion, which the Author assigns to the Terrestrial Globe, as the judgment of *Copernicus*, I know not which he would mean thereby: it is not that questionlesse, which *Copernicus* ascribes unto it conjunctly with the other two, annual and diurnal, which hath nothing to do with declining towards the South and North; but onely serveth to keep the axis of the diurnal revolution continually parallel to it self; so that it must be confest, that either the Authour did not understand this, or that else he dissimbled it. But although this great mistake sufficeth to free us from any obligation of a farther enquiry into his objections; yet nevertheless I shall have them in esteem; as indeed they deserve to be valued much before the many others of impertinent Antagonists. Returning therefore to his objection, I say, that the two motions, annual and diurnal, are not in the least contrary, nay are towards the same way, and therefore may depend on one and the same principle. The third is of it self, and voluntarily so consequential to the annual, that we need not trouble our selves (as I shall shew in its place) to study for principles either internal or external, from which, as from its cause, to make it produced.

SAGR. I shall also, as being induced thereto by natural reason, say something to this Antagonist. He will condemn *Copernicus*, unless I be able to answer him to all objections, and to satisfie him in all questions he shall ask; as if my ignorance were a necessary argument of the falshood of his Doctrine. But if this way of condemning Writers be in his judgment legal, he ought not to think it unreasonable, if I should not approve of *Aristotle* and *Ptolomy*, when he cannot resolve, better than my self, those doubts which I propound to him, touching their Doctrine. He asketh me, what are the principles by which the Terrestrial Globe is moved with the Annual motion through the Zodiack, and with the Diurnal through the Equinoctial about its own axis. I answer, that they are like to those by which *Saturn* is moved about the Zodiack in thirty years, and about its own centre in a much shorter time along the Equinoctial, as the collateral apparition and occultation of its Globes doth evince. They are principles like to those, whereby he scrupleth not to grant, that the Sun runneth thorough the Ecliptick in a year, and revolveth about its own centre parallel to the Equinoctial in lesse than a moneth, as its spots doth sensibly demonstrate. They are things like to those whereby the Medicean Stars run through the Zodiack in twelve years, and all the while revolve in small circles, and short periods of time about *Jupiter*.

SIMP. This Author will deny all these things, as delusions of the sight, caused by the crystals of the Telescope.

SAGR.

*The same argu-
ment answered by
examples of the
like motions in o-
ther celestial bo-
dies.*

SAGR. But this would be to draw a further inconvenience upon himself, in that he holdeth, that the bare eye cannot be deceived in judging of the right motion of descending graves, and yet holds that it is deceived in beholding these other motions at such time as its visive vertue is perfected, and augmented to thirty times as much as it was before. We tell him therefore, that the Earth in like manner partaketh of the plurality of motions: and it is perhaps the same, whereby the Loadstone hath its motion downwards, as grave, and two circular motions, one Horizontal, and the other Vertical under the Meridian. But what more; tell me, *Simplicius*, between which do you think this Author would put a greater difference, 'twixt right and circular motion, or 'twixt motion and rest?

SIMP. 'Twixt motion and rest, certainly. And this is manifest, for that circular motion is not contrary to the right, according to *Aristotle*; nay, he granteth that they may mix with each other; which it is impossible for motion and rest to do.

Motion and rest are more different than right motion and circular.

SAGR. Therefore its a proposition lesse improbable to place in one natural body two internal principles, one to right motion, and the other to circular, than two such interne principles one to motion, and the other to rest. Now both these positions agree to the natural inclination that resideth in the parts of the Earth to return to their whole, when by violence they are divided from it; and they onely dissent in the operation of the whole: for the latter of them will have it by an interne principle to stand still, and the former ascribeth to it the circular motion. But by your confession, and the confession of this Philosopher, two principles, one to motion, and the other to rest, are incompatible together, like as their effects are incompatible: but now this evenes not in the two motions, right, and circular, which have no repugnance to each other.

One may more rationally ascribe to the Earth two internal principles to the right, and circular motion, than two to motion and rest.

SALV. Adde this more, that in all probability it may be that the motion, that the part of the Earth sepatated doth make whilst it returneth towards its whole, is also circular, as hath been already declared; so that in all respects, as far as concernes the present case, Mobility seemeth more likely than Rest. Now proceed, *Simplicius*, to what remains.

The motion of the parts of the Earth returning to their whole may be circular.

SIMP. The Authour backs his Argument with producing another absurdity, that is, that the same motions agree to Natures extremely different; but experience sheweth, that the operations and motions of different natures, are different; and Reason confirmeth the same: for otherwise we should have no way left to know and distinguish of natures, if they should not have their particular motions and operations, that might guide us to the knowledge of their substances.

The diversity of motions helpeth us in knowing the diversity of natures.

SAGR.

*Nature first
made things as she
pleased, and after-
wards capacitated
mens understand-
ings for conceiving
of them.*

SAGR. I have twice or thrice observed in the discourses of this Authour, that to prove that a thing is so, or so, he still alledgeth, that in that manner it is conformable with our understanding; or that otherwise we should never be able to conceive of it; or that the *Criterion* of Philosophy would be overthrown. As if that nature had first made mens brains, and then disposed all things in conformity to the capacity of their intellects. But I incline rather to think that Nature first made the things themselves, as she best liked, and afterwards framed the reason of men capable of conceiving (though not without great pains) some part of her secrets.

SALV. I am of the same opinion. But tell me, *Simplicius*, which are these different natures, to which, contrary to experience and reason, *Copernicus* assigns the same motions and operations.

*Copernicus erroneously assigneth
the same operations
to different natures*

SIMP. They are these. The Water, the Air, (which doubtlesse are Natures different from the Earth) and all things that are in those elements comprised, shall each of them have those three motions, which *Copernicus* pretends to be in the Terrestrial Globe; and my Authour proceedeth to demonstrate Geometrically, that, according to the *Copernican* Doctrine, a cloud that is suspended in the Air, and that hangeth a long time over our heads without changing place, must of necessity have all those three motions that belong to the Terrestrial Globe. The demonstration is this, which you may read your self, for I cannot repeat it without book.

SALV. I shall not stand reading of it, nay I think it an impertinency in him to have inserted it, for I am certain, that no *Copernican* will deny the same. Therefore admitting him what he would demonstrate, let us speak to the objection, which in my judgment hath no great strength to conclude any thing contrary to the *Copernican Hypothesis*, seeing that it derogates nothing from those motions, and those operations, whereby we come to the knowledge of the natures, &c. Answer me, I pray you, *Simplicius*: Those accidents wherein some things exactly concur, can they serve to inform us of the different natures of those things?

*From common
accidents one cannot
know different
natures.*

SIMP. No Sir: nay rather the contrary, for from the identity of operations and of accidents nothing can be inferred, but an identity of natures.

SALV. So that the different natures of the Water, Earth, Air, and other things contained in these Elements, is not by you argued from those operations, wherein all these Elements and their affixes agree, but from other operations; is it so?

SIMP. The very same.

SALV. So that he who should leave in the Elements all those motions,

motions, operations, and other accidents, by which their natures are distinguished, would not deprive us of the power of coming to the knowledge of them; although he should remove those operations, in which they unitedly concur, and which for that reason are of no use for the distinguishing of those natures.

SIMP. I think your dissertation to be very good.

SALV. But that the Earth, Water, Air, are of a nature equally constituted immoveable about the centre, is it not the opinion of your self, *Aristotle*, *Prology*, and all their sectators?

SIMP. Its on all hands granted as an undeniable truth.

SALV. Then from this common natural condition of quiescence about the centre, there is no argument drawn of the different natures of these Elements, and things elementary, but that knowledge must be collected from other qualities not common; and therefore who should deprive the Elements of this common rest only, and should leave unto them all their other operations, would not in the least block up the way that leadeth to the knowledge of their essences. But *Copernicus* depriveth them onely of this common rest, and changeth the same into a common motion, leaving them gravity, levity, the motions upwards, downwards, slower, faster, rarity, density, the qualities of hot, cold, dry, moist, and in a word, all things besides. Therefore such an absurdity, as this Authour imagineth to himself, is no *Copernican* position; nor doth the concurrence in an identity of motion import any more or less, than the concurrence in an identity of rest about the diversifying, or not diversifying of natures. Now tell us, if there be any argument to the contrary.

SIMP. There followeth a fourth objection, taken from a natural observation, which is, *That bodies of the same kind, have motions that agree in kinde, or else they agree in rest.* But by the *Copernican* Hypothesis, *bodies that agree in kinde, and are most sensible to one another, would be very discrepant, yea diametrically repugnant as to motion; for that Stars so like to one another, would be neverthelesse so unlike in motion, as that six Planets would perpetually turn round; but the Sun and all the fixeed Stars would stand perpetually immoveable.*

SALV. The forme of the argument appeareth good; but yet I believe that the application of matter is defective: and if the Authour will but persist in his assumption, the consequence shall make directly against him. The Argument runs thus; Amongst mundane bodies, fix there are that do perpetually move, and they are the six Planets; of the rest, that is, of the Earth, Sun, and fixed Stars, it is disputable which of them moveth, and which stands still, it being necessary, that if the Earth stand still, the Sun and fixed Stars do move; and it being also possible, that the Sun

The concurrence of the Elements in a common motion importeth no more or less, than their concurrence in a common rest.

A fourth argument against Copernicus.

Bodies of the same kinde have motions that agree in kinde.

From the Earths obscurity, and the splendour of the Sun, and fixed Stars, is argued, that it is moveable, and they immoveable.

and fixed Stars may stand immoveable, in case the Earth should move: the matter of fact in dispute is, to which of them we may with most convenience ascribe motion, and to which rest. Natural reason dictates, that motion ought to be assigned to the bodies, which in kind and essence most agree with those bodies which do undoubtedly move, and rest to those which most dissent from them; and in regard that an eternal rest and perpetual motion are most different, it is manifest, that the nature of the body always moveable ought to be most different from the body always stable. Therefore, in regard that we are dubious of motion and rest, let us enquire, whether by the help of some other eminent affection, we may discover, which most agreeth with the bodies certainly moveable, either the Earth, or the Sun and fixed Stars. But see how Nature, in favour of our necessity and desire, presents us with two eminent qualities, and no less different than motion and rest, and they are light and darkness, to wit, the being by nature most bright, and the being obscure, and wholly deprived of light: the bodies therefore adorned with an internal and eternal splendour, are most different in essence from those deprived of light: The Earth is deprived of light; the Sun is most splendid in it self, and so are the fixed Stars. The six Planets do absolutely want light, as the Earth; therefore their essence agreeth with the Earth, and differeth from the Sun and fixed Stars. Therefore is the Earth moveable, immoveable the Sunne and Starry Sphere.

SIMP. But the Authour will not grant, that the six Planets are tenebrous, and by that negative will he abide. Or he will argue the great conformity of nature between the six Planets, and the Sun, and Fixed Stars; and the disparity between them and the Earth from other conditions than from tenebrosity and light; yea, now I remember in the fifth objection, which followeth, he layeth down the vast difference between the Earth and the Cœlestial Bodies, in which he writeth, *That the Copernican Hypothesis would make great confusion and perturbation in the Systeme of the Universe, and amongst its parts:* As for instance, amongst Cœlestial bodies that are immutable and incorruptible, according to *Aristotle, Tycho*, and others; amongst bodies, I say, of such nobility, by the confession of every one, and *Copernicus* himself, who affirmeth them to be ordinate, and disposed in a perfect constitution, and removeth from them all inconstancy of vertue amongst these bodies, I say once more, so pure, that is to say, amongst *Venus, Mars, &c.* to place the very sink of all corruptible matters, to wit, the Earth, Water, Air, and all mixt bodies.

But how much properer a distribution, and more with nature, yea with God himself, the Architect, is it, to sequester the pure from

A fifth argument against Copernicus.

Another difference between the Earth and the Cœlestial bodies, taken from purity & impurity.

from the impure, the mortal from the immortal, as other Schools teach; which tell us that these impure and frail matters are contained within the angust concave of the Lunar Orb, above which with uninterrupted Series the things Celestial distend themselves.

SALV. It's true that the Copernican Systeme introduceth distraction in the universe of *Aristotle*; but we speak of our own Universe, that is true and real. Again if this Author will infer the disparity of essence between the Earth and Celestial bodies from the incorruptibility of them, and the corruptibility of it in the method of *Aristotle*; from which disparity he concludeth motion to belong to the Sun and fixed Stars, and the immobility of the Earth; he will flatter himself with a Paralogisme, supposing that which is in question; for *Aristotle* inferreth the incorruptibility of Celestial bodies from motion, which is in dispute, whether it belongeth to them or to the Earth. Of the vanity of these Rhetorical Illations enough hath been spoken. And what can be more fond, than to say, that the Earth and Elements are banished and sequestred from the Celestial Spheres, and confined within the Lunar Orb? Is, not then the Moons Orb one of the Celestial Spheres, and according to consent comprised in the middle of all the rest? Its a new way to separate the pure from the impure, and the sick from the sound, to assigne the infected quarters in the heart of the City: I had thought that the * Pest-house ought to have been removed as far off as was possible. *Copernicus* admireth the disposition of the parts of the Universe, for that God hath constituted the grand Lamp, which is to give light all over his Temple in the centre of it, and not on one side. And as to the Earths being betwixt *Venus* and *Mars*, we will but hint the same; and do you, in favour of this Author, trie to remove it thence. But let us not * mix these Rhetorical Flowers with solid Demonstrations; rather let us leave them to the Orators, or if you will to the Poets, who know how in their drolling way to exalt by their prayes things most sordid, yea and sometimes most pernicious. And if any thing else remain, let us dispatch it, as we have done the rest.

SIMP. There is the sixth and last argument, wherein he maketh it a very improbable thing. [That a corruptible and dissipable body should move with a perpetual and regular motion; and this he confirmeth with the example of living creatures, which moving with a motion natural to them, yet grow weary, and have need of repose to restore their strength.] But what hath this motion to do with that of the Earth; that in comparifon to theirs is immense? Besides, to make it move with three motions that run and draw several wayes: Who would ever assert such Paradoxes, unless he had sworn to be their defender? Nor doth that avail in this case,

Copernicus is introduceth confusion in the Universe of Aristotle.

The Paralogisme of the Author of Anti-Tycho.

It seemeth a folly to affirm the Earth to be without the Heavens.

* Lazeretto

* Intrecciare, to twine flowers in a garland.

A sixth argument against Copernicus, taken from animals, who have need of rest, though their motion be natural.

case, which *Copernicus* alledgeth, that by reason this motion is natural to the Earth and not violent, it worketh contrary effects to violent motions; and that those things dissolve and cannot long subsist, to which impulse is conferred, but those so made by nature do continue in their perfect disposure; this answer sufficeth not, I say, for it is overthrown by that of ours. For the animal is a natural body, and not made by art, and its motion is natural, deriving it self from the soul, that is, from an intrinsic principle; and that motion is violent, whose beginning is without, and on which the thing moved conferreth nothing; however, if the animal continueth its motion any long time, it grows weary, and also dyeth, if it obstinately strive to persist therein. You see then that in nature we meet on all sides with notions contrary to the *Copernican Hypothesis*, and none in favour of it. And for that I have nothing more wherein to take the part of this Opponent, hear what he produceth against *Keplerus* (with whom he disputeth) upon that argument, which the said *Kepler* bringeth against those who think it an inconvenient, nay impossible thing, to augment the Starry Sphere immensely, as the *Copernican Hypothesis* requireth. *Kepler* therefore instanceth, saying: *Difficilius est, accidens præter modulum subjecti intendere, quam subjectum sine accidente augere. Copernicus ergo verisimilius facit, qui augeat Orbem Stellarum fixarum absque motu, quam Ptolomæus, qui augeat motum fixarum immensa velocitate.* [Which makes this English.] Its harder to stretch the accident beyond the model of the subject than to augment the subject without the accident. *Copernicus* hath more probability on his side, who encrease the Orb of the fixed Stars without motion, than *Ptolomy* who augmenteth the motion of the fixed Stars to an immense degree of velocity. Which objection the Author answereth, wondering how much *Kepler* deceived himself, in saying, that in the *Ptolomaick Hypothesis* the motion encrease beyond the model of the subject, for in his judgment it doth not encrease, save onely in conformity to the model, and that according to its encrease, the velocity of the motion is augmented. Which he proveth by supposing a machine to be framed, that maketh one revolution in twenty four hours, which motion shall be called most slow; afterwards supposing its semidiameter to be prolonged, as far as to the distance of the Sun, its extreme will equal the velocity of the Sun; and it being continued out unto the Starry Sphere, it will equal the velocity of the fixed Stars, though in the circumference of the machine it be very slow. Now applying this consideration of the machine to the Starry Sphere, let us imagine any point in its semidiameter, as neer to the centre as is the semidiameter of the machine; the same motion that in the Starry Sphere is exceeding swift,

An argument
from *Kepler* in fa-
vour of *Coperni-*
cus.

The Author of
the *Anti-Tycho* op-
poseth *Kepler*.

The velocity of
the circular moti-
on increaseth, ac-
cording to the en-
crease of the dia-
meter of the circle.

swift, shall in that point be exceeding slow; But the great magnitude of the body is that which maketh it of exceeding flow, to become exceeding swift, although it continueth still the same, and thus the velocity encreaseth, not beyond the model of the subject, but rather according to it, and to its magnitude; very differently from the imagination of *Kepler*.

SALV. I do not believe that this Author hath entertained so mean and poor a conceit of *Kepler*, as to perswade himself that he did not understand, that the highest term of a line drawn from the centre unto the Starry Sphere, moveth more swiftly than a point of the same line taken within a yard or two of the centre. And therefore of necessity he must have conceived and comprehended that the mind and intention of *Kepler* was to have said, that it is lesse inconvenient to encrease an immoveable body to an extraordinary magnitude, than to ascribe an extraordinary velocity to a body, though very bigge, having regard to the model, that is to the gauge, and to the example of other natural bodies; in which we see, that the distance from the centre encreasing, the velocity diminisheth; that is, that the periods of their circulations take up longer times. But in rest which is not capable of augmentation or diminution, the grandure or smalnesse of the body maketh no difference. So that if the answer of the Author would be directed against the argument of *Kepler*, it is necessary, that that Author doth hold, that to the movent principle its one and the same to move in the same time a body very small, or very immense, in regard that the augmentation of velocity inseparably attends the augmentation of the masse. But this again is contrary to the Architectonical rule of nature, which doth in the lesser Spheres, as we see in the Planets, and most sensibly in the Medicean Stars, observe to make the lesser Orbs to circulate in shorter times: Whence the time of *Saturnus* revolution is longer than all the times of the other lesser Spheres, it being thirty years; now the passing from this to a Sphere very much bigger, and to make it move in 24. hours, may very well be said to exceed the rules of the model. So that if we would but attentively consider it, the Authors answer opposeth not the intent and sense of the argument, but the expressing and manner of delivering of it; where again the Author is injurious, and cannot deny but that he artificially dissembled his understanding of the words, that he might charge *Kepler* with grosse ignorance; but the imposture was so very dull and obviouse, that he could not with all his craft alter the opinion which *Kepler* hath begot of his Doctrine in the minds of all the Learned. As in the next place, to the instance against the perpetual motion of the Earth, taken from the impossibility of its moving long without wearinesse, in regard that living crea-

H h 2

tures

*An explanation
of the true sense of
Kepler and his de-
fence.*

*The greatnesse
and smalnesse of
the body make a
difference in moti-
on and not in rest.*

*The order of na-
ture is to make the
lesser Orbs to cir-
culate in shorter
times, and the big-
ger in longer times.*

tures themselves, which yet move naturally, and from an intern principle, do grow weary, and have need of rest to relax and refresh their members —

The feigned answer of Kepler covered with an artificial Irony.

SAGR. Methinks I hear *Kepler* answer him to that, that there are some kinde of animals which refresh themselves after wearinesse, by rowling on the Earth; and that therefore there is no need to fear that the Terrestrial Globe should tire, nay it may be reasonably affirmed, that it enjoyeth a perpetual & most tranquil repose, keeping it self in an eternal rowling.

SALV. You are too tart and Satyricall, *Sagredus*: but let us lay aside jests, whilst we are treating of serious things.

Animals would not grow weary of their motion, proceeding as that which is assigned to the terrestrial Globe.

The cause of the wearinesse of animals.

The motion of an animal is rather to be called violent than natural.

The strength diminisheth not, where it is not employed.

SAGR. Excuse me, *Salviatus*; this that I say is not so absolutely besides the business, as you perhaps make it; for a motion that serveth instead of rest, and removeth weariness from a body tired with travail, may much more easily serve to prevent the coming of that weariness, like as preventive remedies are more easie than curative. And I hold for certain, that if the motion of animals should proceed in the same manner as this that is ascribed to the Earth, they would never grow weary. Seeing that the weariness of the living creature, deriveth it self, in my opinion, from the imployment of but one part alone in the moving of its self, and all the rest of the body; as e. g. in walking, the thighs and the legs onely are imployed for carrying themselves and all the rest: on the contrary, you see the motion of the heart to be as it were indefatigable, because it moveth it self alone. Besides, I know not how true it may be, that the motion of the animal is natural, and not rather violent: nay, I believe that one may truly say, that the soul naturally moveth the members of an animal with a motion preternatural, for if the motion upwards is preternatural to grave bodies, the lifting up of the legs, and the thighs, which are grave bodies, in walking, cannot be done without violence, and therefore not without labour to the mover. The climbing upwards by a ladder carrieth the grave body contrary to its natural inclination upwards, from whence followeth weariness, by reason of the bodies natural avernesse to that motion: but in moving a moveable with a motion, to which it hath no aversion, what lassitude, what diminution, of vertue and strength need we fear in the mover? and how should the forces waste, where they are not at all imployed?

SIMP. They are the contrary motions wherewith the Earth is pretended to move, against which the Authour produceth his argument.

SAGR. It hath been said already, that they are no wise contraries, and that herein the Authour is extreamly deceived, so that the whole strength of the argument recoileth upon the Opponent

ponent himself; whilst he will make the *First Mover* to hurry along with it all the inferiour Spheres, contrary to the motion which they themselves at the same time exercise. It belongs therefore to the *Primum Mobile* to grow weary; which besides the moving of its self is made to carry so many other Spheres, and which also strive against it with a contrary motion. So that the ultimate conclusion that the Authour inferred, saying, that discoursing of the effects of Nature, a man alwayes meets with things that favour the opinion of *Aristotle* and *Ptolomy*, and never any one that doth not interfere with *Copernicus*, stands in need of great consideration; and it is better to say, that one of these two *Hypotheses* being true, and the other necessarily false, it is impossible that a man should ever be able to finde any argument, experience, or right reason, in favour of that which is false, likewise to the truth none of these things can be repugnant. Vast difference, therefore, must needs be found between the reasons and arguments produced by the one and other party, for and against these two opinions, the force of which I leave you your self to judge of, *Simplicius*.

SALV. But you, *Sagredus*, being transported by the velocity of your wit, have taken my words out of my mouth, whilst I was about to say something, touching this last argument of the Author; and although you have more then sufficiently refuted him, yet nevertheless I will adde somewhat, which then ran in my minde. He proposeth it as a thing very unlikely, that a body dissipable and corruptible, as the Earth, should perpetually move with a regular motion, especially for that we see living creatures in the end to grow weary, and to stand in need of rest: and the improbability is increased, in that the said motion is required to be of velocity incomparable and immense, in respect to that of animals. Now, I cannot see why the velocity of the Earth should, at present, trouble it; so long as that of the starry Sphere so very much bigger doth not occasion in it any disturbance more considerable, than that which the velocity of a machine, that in 24 hours maketh but one sole revolution, produceth in the same. If the being of the velocity of the Earths conversion, according to the model of that machine, inferreth things of no greater moment than that, let the Author cease to fear the Earths growing weary; for that not one of the most feeble and slow-paced animals, no not a *Chamæleon* would tire in moving no more than * four or five yards in 24 hours; but if he please to consider the velocity to be no longer, in relation to the model of the machine, but absolutely, and inasmuch as the moveable in 24 hours is to pass a very great space, he ought to shew himself so much more reserved in granting it to the starry Sphere, which with a velocity incomparably greater than that of the Earth

The arguments of Claramontius, recoileth upon himself.

True Propositions meet with many conclusive arguments, so do not the false.

* Cinque ô sei braccia Fiorentini. Weariness more to be feared in the starry Sphere than in the terrestriall Globe.

Earth is to carry along with it a thousand bodies, each much bigger than the Terrestrial Globe.

Here it remains for us to see the proofs, whereby the Authour concludes the new stars *Anno 1572.* and *Anno 1604.* to be sublunary, and not celestial, as the *Astronomers* of those times were generally perswaded; an enterprize very great certainly; but I have considered, that it will be better, in regard the Book is new and long, by reason of its many calculations, that between this evening and to morrow morning I make them as plain as I can, and so meeting you again to morrow to continue our wonted conferences, give you a brief of what I shall observe therein; and if we have time left, we will say something of the *Annual motion* ascribed to the Earth. In the mean time, if either of you, and *Simplicius* in particular, hath any thing to say more, touching what relates to the *Diurnal motion*, at large examined by me, we have a little time still left to treat thereof.

SIMP. I have no more to say, unlesse it be this, that the discourses that this day have fallne under our debate, have appeared to me fraught with very acute and ingenious notions, alledged on *Copernicus* his side, in confirmation of the motion of the Earth, but yet I find not my self perswaded to believe it; for in short, the things that have been said conclude no more but this, that the reasons for the stability of the Earth are not necessary; but all the while no demonstration hath been produced on the other side, that doth necessarily convince and prove its mobility.

SALV. I never undertook, *Simplicius*, to remove you from that your opinion; much less dare I presume to determine definitively in this controversie: it onely was, and still shall be in the ensuing disputations my intent, to make it appear to you, that those who have thought that most swift motion of 24 hours doth belong to the Earth alone, and not to the Universe, the Earth onely excluded, were not induced to believe, that so it might and ought to do out of any blind perswasion; but that they did very well see, try, and examine the reasons on the contrary side, and also not slightly answer them. With the same intention, if it stand with your liking, and that of *Sagredus*, we may passe to the consideration of that other motion; first, by *Aristarchus Samius*, and afterwards by *Nicholaus Copernicus* ascribed to the said Terrestrial Globe, which is, as, I believe, you have heretofore heard, made under the Zodiack within the space of a year about the Sun, immoveably placed in the centre of the said Zodiack.

SIMP. The disquisition is so great, and so noble, that I shall gladly hearken to the discussion thereof, perswading my self that I shall hear what ever can be said of that matter. And I will afterwards

DIALOGUE II.

wards by my self, according to my usual custome, make more deliberate reflexions upon what hath been, and is to be spoken ; and if I should gain no more but this, it will be no small benefit that I shall be able to discourse more Logically.

SAGR. Therefore, that we may no further weary *Salviatus*, we will put a period to the disputations of this day, and reassume our conference to morrow in the usual manner, with hope to hear very pleasing novelties.

SIMP. I will leave with you the Book *De stellis novis*, and carry back this of the Conclusions, to see what is written therein against the Annual motion, which are to be the arguments of our discourse to morrow.



THESEUS

Theseus was a famous king of Athens, and a great warrior. He was the son of King Demetrius, and his mother was Queen Phaedra. He was a very brave and noble man, and he was very kind to his subjects. He was a great leader, and he was a great warrior. He was a very famous king, and he was a great warrior. He was a very brave and noble man, and he was very kind to his subjects. He was a great leader, and he was a great warrior.

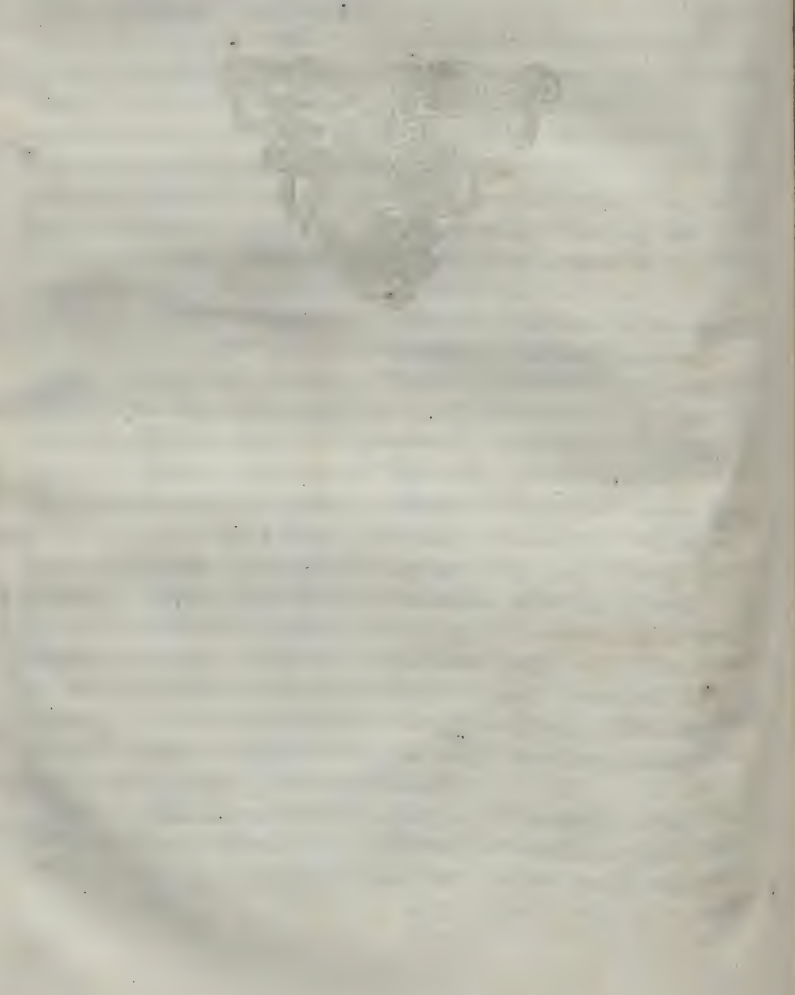


Fig: 1:

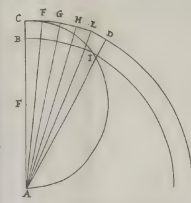


Fig: 2:

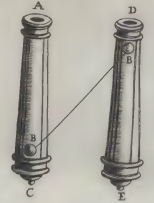


Fig: 3:

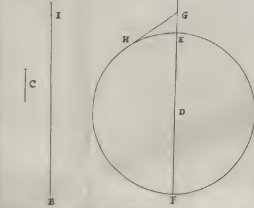


Fig: 4:

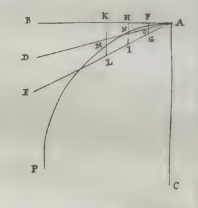


Fig: 5:

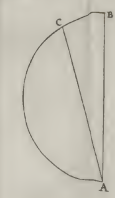


Fig: 6:

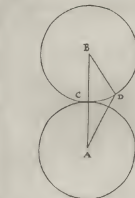


Fig: 7:

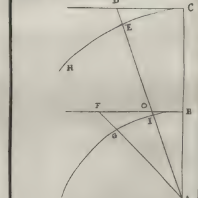


Fig: 8:

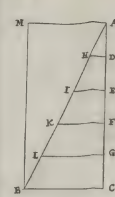


Fig: 9:



Place this Plate
at the end of
the Second
Dialogue.



BIBLIOTHECA
UNIVERSITATIS
HAUNIENSIS

BIBLIOTHECA
UNIVERSITATIS
HAUNIENSIS

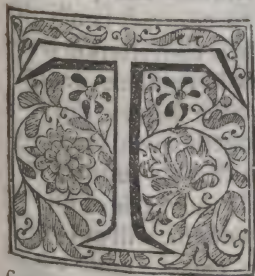
GALILÆUS
Galilæus Lynceus,
HIS
SYSTEME
OF THE
WORLD.

The Third Dialogue.

INTERLOCUTORS.

SALVIATUS, SAGREDUS, and SIMPLICIUS.

SAGR.



He great desire wherewith I have expected your coming, that I might hear the novel conceits touching the annual conversion of this our Globe, hath made me think the houres of the last night, and those of this morning very tedious, although I spent them not idly, but lying awake I imployed a good part thereof in ruminating upon our yesterdaies discourses, weighing the reasons alledged by both parties, in favour of the two contrary Hypotheses, that of *Aristotle* and *Ptolomy*, and this of *Aristarchus*, and *Copernicus*. And really methinks, that which ever of these parties have been deceived, they are worthy of excuse, so specious and valid in appearance are the reasons that may have perswaded them either way; though neverthelesse we

Ii

do

do for the most part close with those produced by the grave Authours first above mentioned. But albeit that the *Peripatetick Hypothesis*, by reason of its antiquity, hath had many followers and fautors, and the other very few; first, for its obscurity, and next, for its novelty, yet methinks I discover amongst those many, and particularly amongst the modernes some, who for the support of the opinion by them esteemed true, have introduced other reasons sufficiently childish, I could say ridiculous.

Some in arguing first fix in their minds the conclusion beleev'd by them, and then adapt their reasons to that.

SALV. I have met with the like, and so much worse than yours, that I blush to rehearse them, not so much to spare the fame of their Authours, the names of whom might be perpetually concealed, as because I am ashamed so much to stain the honour of mankind. In observing of these men, I have found that some there are who preposterously reasoning, first stablish the conclusion in their fancy, and (either because it is their own, or else belongs to a person whom they much confide in) so firmly imprint it in their opinions, that it is altogether impossible ever wholly to efface it: and those reasons which they themselves stumble upon, or which they hear others to alledge in confirmation of the conceit entertained, though never so simple and insipid, instantly find credit and applause with them: but on the contrary, those which are brought against their opinion, though ingenuous and concluding, they receive not only with nauseating, but with disdain and bitter indignation, yea, you shall have one of these so enraged, as that he will not be backward to try all wayes to suppress and silence their adversaries: and of this I my self have had some experience.

SAGR. Indeed these men deduce not the conclusion from the premises, nor confirm them with reasons, but accomodate, or to say better, discomodate and distort the premises and arguments to make them speak in favour of their pre-assumed and pertinacious conclusions. It is not good therefore to contract familiarity with these men; and the rather, for that their conversation is not only unpleasant, but also dangerous. Yet let us continue our conference with *Simplicius* however, whom I have known this long while for a man of great ingenuity, and altogether void of malice: besides he is well vers'd in the *Peripatetick Doctrine*; so that I may assure my self, that what shall not fall within the reach of his reason for the support of the *Aristotelian Hypothesis*, will not easily be found out by others. But see yonder he comes, quite out of winde, whose company we have so long desired: we were just now speaking against the small hast you made to come to us.

SIMP. You must not blame me, but *Neptune*, for this my long stay; which in the ebbe of this mornings tide hath in a manner drain'd away the waters, for the *Gondola* that brought me, being entered not far from hence into a certain Channel, wanting depth, where

where I was stranded, and forced to stay there more than a full hour, in expecting the return of the tide: and there waiting in this manner; without being able to get out of the boat, which on a sudden ran a ground, I observed a certain accident, which to me seemed very strange; and it was this, that in the waters ebbing I saw it retreat very fast by several small rivolets, the ouze being in many places discovered, and whilst I stood looking upon this effect, I saw this motion in an instant to cease, and without a minutes interval the same water to begin to return back again, and the tide from ebbing to become young flood, without standing still a moment: an effect that as long as I have dwelt in Venice, I never took notice of before.

The motion of the water in ebbing and flowing not interrupted by rest.

SAGR. It is very much, that you should be left thus on ground, amongst small Channels; in which rivolets, as having very little declivity, the rising or falling of the main sea, the thickness onely of a paper is sufficient to make the water to ebbe and flow for good long spaces of time: like as in some creeks of the Sea, its flowing four or six * yards onely, maketh the water to overflow the adjacent Marshes for some hundreds and thousands of * acres.

* Pertiche venetiani.

SIMP. This I know very well, but I should have thought, that between the ultimate terme of ebbing, and the first beginning to flow, there should have interposed some considerable interval of rest.

SAGR. This will appear unto you, if you cast your eye upon the bank or piles, where these mutations are made perpendicularly, but not that there is any real time of cessation.

SIMP. I did think, that because these two motions were contrary, there ought to be in the midst between them some kind of rest; conformable to the Doctrine of Aristotle, which demonstrates that *in puncto regressus mediat quies*.

SAGR. I very well remember this place: but I bear in minde also, that when I read Philosophy, I was not thorowly satisfied with Aristotles demonstration; but that I had many experiments on the contrary, which I could still rehearse unto you, but I am unwilling to fall out into any other digressions, we being met here to discourse of the proposed mattes, if it be possible, without these excursions wherewith we have interrupted our disputes in those dayes that are past.

SIMP. And yet we may with convenience, if not interrupt them, at least prolong them very much, for returning yesterday home, I set my self to read the Tractate of Conclusions, where I find Demonstrations against this annual motion ascribed to the Earth, very solid; and because I would not trust my memory with the punctual relation of them, I have brought back the Book along with me.

SAGR. You have done very well; but if we would re-assume our Disputations according to yesterdaies appointment, it is requisite that we first hear what account *Salviatus* hath to give us of the Book, *De stellis novis*, and then without interruption we may proceed to the Annual motion. Now what say you, *Salviatus* touching those stars? Are they really pull'd down from Heaven to these lower regions, by vertue of that Authours calculations, whom *Simplicius* mentioneth?

SALV. I set my self last night to peruse his proceedings, and I have this morning had another view of him, to see whether that which he seem'd over night to affirm, were really his sense, or my dreams and phantastical nocturnal imaginations; and in the close found to my great grief that those things were really written and printed, which for the reputation-sake of this Philosopher I was unwilling to believe. It is in my judgment impossible, but that he should perceive the vanity of his undertaking, aswell because it is too apert, as because I remember, that I have heard him mentioned with applause by the *Academick our Friend*: it seemeth to me also to be a thing very unlikely, that in complacency to others, he should be induced to set so low a value upon his reputation, as to give consent to the publication of a work, for which he could expect no other than the censure of the Learned.

SAGR. Yea, but you know, that those will be much fewer than one for an hundred, compared to those that shall celebrate and extoll him above the greatest wits that are, or ever have been in the world: He is one that hath mentioned the Peripatetick inalterability of Heaven against a troop of *Astronomers*, and that to their greater disgrace hath foiled them at their own weapons; and what do you think four or five in a Countrey that discern his triflings, can do against the innumerable multitude, that, not being able to discover or comprehend them, suffer themselves to be taken with words, and so much more applaud him, by how much the lesse they understand him? You may adde also, that those few who understand, scorn to give an answer to papers so trivial and unconcludent; and that upon very good reasons, because to the intelligent there is no need thereof, and to those that do not understand, it is but labour lost.

SALV. The most deserved punishment of their demerits would certainly be silence, if there were not other reasons, for which it is haply no lesse than necessary to resent their timerity: one of which is, that we *Italians* thereby incur the censure of *Illiterates*, and attract the laughter of *Forreigners*; and especially to such who are separated from our Religion; and I could shew you many of those of no small eminency, who scoff at our *Academick*, and the many *Mathematicians* that are in *Italie*, for suffering the
follies

* Lorzerzini.

follies of such a * Fabler against *Astronomers* to come into the light, and to be openly maintained without contradiction; but this also might be dispensed with, in respect of the other greater occasions of laughter, wherewith we may confront them depending on the dissimulation of the intelligent, touching the follies of these opponents of the Doctrines that they well enough understand.

SAGR. I desire not a greater proof of those mens petulancy, and the infelicity of a *Copernican*, subject to be opposed by such as understand not so much as the very first positions, upon which he undertakes the quarrel.

SALV. You will be no lesse astonished at their method in confuting the *Astronomers*, who affirm the new Stars to be superiour to the Orbs of the Planets; and peradventure in the † Firmament it self.

† He taketh the Firmament for the Starry Sphere, and as we vulgarly receive the word.

SAGR. But how could you in so short a time examine all this Book, which is so great a Volume, and must needs contain very many demonstrations?

SALV. I have confined my self to these his first confutations, in which with twelve demonstrations founded upon the observations of twelve *Astronomers*, (who all held, that the Star, Anno 1572. which appeared in *Cassiopeia*, was in the Firmament), he proveth it on the contrary, to be beneath the Moon, conferring, two by two, the meridian altitudes, proceeding in the method that you shall understand by and by. And because, I think, that in the examination of this his first progression, I have discovered in this Authour a great unlikelihood of his ability to conclude any thing against the *Astronomers*, in favour of the *Peripatetick Philosophers*, and that their opinion is more and more conclusively confirmed, I could not apply my self with the like patience in examining his other methods, but have given a very slight glance upon them, and am certain, that the defect that is in these first impugnations, is likewise in the rest. And as you shall see, by experience, very few words will suffice to confute this whole Book, though compiled with so great a number of laborious calculations, as here you see. Therefore observe my proceedings. This Authour undertaketh, as I say, to wound his adversaries with their own weapons, i.e. a great number of observations made by themselves, to wit, by twelve or thirteen Authours in number, and upon part of them he makes his supputations, and concludeth those stars to have been below the Moon. Now because the proceeding by interrogatories very much pleaseth me, in regard the Authour himself is not here, let *Simplicius* answer me to the questions that I shall ask him, as he thinks he himself would, if he were present. And presupposing that we speak of the foresaid Star, of Anno 1572. appearing

The method observed by Clar, in confuting the *Astronomers*, and by *Salvatus* in confuting him.

pearing in *Cassiopeia*, tell me, *Simplicius*, whether you believe that it might be in the same time placed in divers places, that is, amongst the Elements, and also amongst the planetary Orbs, and also above these amongst the fixed Stars, and yet again infinitely more high.

SIMP. There is no doubt, but that it ought to be confessed that it is but in one only place, and at one sole and determinate distance from the Earth.

SALV. Therefore if the observations made by the Astronomers were exact, and the calculations made by this Author were not erroneous, it were easie from all those and all these to recollect the same distances alwayes to an hair, is not this true?

SIMP. My reason hitherto tells me that so it must needs be; nor do I believe that the Author would contradict it.

SALV. But when of many and many computations that have been made, there should not be so much as two onely that prove true, what would you think of them?

SIMP. I would think that they were all false, either through the fault of the computist, or through the defect of the observers, and at the most that could be said, I would say, that but onely one of them and no more was true; but as yet I know not which to choose.

SALV. Would you then from false fundamentals deduce and establish a doubtful conclusion for true? Certainly no. Now the calculations of this Author are such, that no one of them agrees with another; you may see then what credit is to be given to them.

SIMP. Indeed, if it be so, this is a notable failing.

SAGR. But by the way I have a mind to help *Simplicius*, and the Author by telling *Salviatus*, that his arguments would hold good if the Author had undertook to go about to find out exactly the distance of the Star from the Earth, which I do not think to be his intention; but onely to demonstrate that from those observations he collected that the Star was sublunary. So that if from those observations, and from all the computations made thereon, the height of the Star be alwayes collected to be lesse than that of the Moon, it serves the Authors turn to convince all those Astronomers of most impardonable ignorance, that through the defect either of Geometry or Arithmetick, have not known how to draw true conclusions from their own observations themselves.

SALV. It will be convenient therefore that I turn my self to you, *Sagredus*, who so cunningly uphold the Doctrine of this Author. And to see whether I can make *Simplicius*, though not very expert in calculations, and demonstrations to apprehend the
in-

inconclusiveness at least of the demonstrations of this Author, first proposed to consideration, and how both he, and all the Astronomers with whom he contendeth, do agree that the new Star had not any motion of its own, and onely went round with the diurnal motion of the *primum mobile*; but dissent about the placing of it, the one party putting it in the Celestial Region, that is above the Moon, and haply above the fixed Stars, and the other judging it to be neer to the Earth, that is, under the concave of the Lunar Orb. And because the situation of the new star, of which we speak, was towards the North, and at no very great distance from the Pole, so that to us *Septentrionals*, it did never set; it was an easie matter with Astronomical instruments to have taken its several meridian altitudes, as well its smallest under the Pole, as its greatest above the same; from the comparing of which altitudes, made in several places of the Earth, situate at different distances from the North, that is, different from one another in relation to polar altitudes, the stars distance might be inferred: For if it was in the Firmament amongst the other fixed stars, its meridian altitudes taken in divers elevations of the pole, ought necessarily to differ from each other with the same variations that are found amongst those elevations themselves; that is, for example, if the elevation of the star above the horizon was 30 degrees, taken in the place where the polar altitude was *v. gr.* 45 degrees, the elevation of the same star ought to have been encreased 4. or 5 degrees in those more Northernly places where the pole was higher by the said 4 or 5 degrees. But if the stars distance from the Earth was but very little, in comparison of that of the Firmament; its meridian altitudes ought approaching to the North to encrease considerably more than the polar altitudes; and by that greater encrease, that is, by the excesse of the encrease of the stars elevation, above the encrease of the polar elevation (which is called the difference of Parallaxes) is readily calculated with a cleer and sure method, the stars distance from the centre of the Earth. Now this Author taketh the observations made by thirteen Astronomers in sundry elevations of the pole, and conferring a part of them at his pleasure, he computeth by twelve collations the new stars height to have been alwayes beneath the Moon; but this he adventures to do in hopes to find so grosse ignorance in all those, into whose hands his book might come, that to speak the truth, it hath turn'd my stomach; and I wait to see how those other Astronomers, and particularly Kepler, against whom this Author principally inveigheth, can contain themselves in silence, for he doth not use to hold his tongue on such occasions; unlesse he did possibly think the enterprize too much below him. Now to give you to

The greatest and least elevations of the new star differ not from each other more than the polar altitudes, the said star being in the Firmament.

un-

understand the same, I have upon this paper transcribed the conclusions that he inferreth from his twelve indagations; the first of which is upon the two observations:

Of *Maurolicus* and *Hainzelius*, from which the Star is collected to have been distant from the centre lesse than 3 semidiameters of the Earth, the difference of Parallaxes being 4 gr. 42 m. 30 sec. ————— 3 semid.

2. And is calculated on the observations of *Hainzelius*, with Parall. of 8 m. 30 sec. and its distance from the centre is computed to be more than ————— 25 semid.
3. And upon the observations of *Tycho* and *Hainzelius*, with Parall. of 10 m. and the distance of the centre is collected to be little lesse than ————— 19 semid.
4. And upon the observations of *Tycho* and the *Landgrave*, with Parall. of 14 m. the distance from the centre is made to be about ————— 10 semid.
5. And upon the observations of *Hainzelius* and *Gemma*, with Parall. of 42 m. 30 sec. whereby the distance is gathered to be about ————— 4 semid.
6. And upon the observations of the *Landgrave* and *Camerarius*, with Parall. of 8 m. the distance is concluded to be about ————— 4 semid.
7. And upon the observations of *Tycho* and *Hagecius*, with Parall. of 6 m. and the distance is made ————— 31 semid.
8. And upon the observations of *Hagecius* and *Ursinus* with Parall. of 43 m. and the stars distance from the superficies of the Earth is rendred ————— $\frac{1}{2}$ semid.
9. And upon the observations of *Landgravius* and *Buschius*, with Parall. of 15 m. and the distance from the superficies of the Earth is by supputation ————— $\frac{1}{4}$ semid.
10. And upon the observations of *Maurolice* and *Munocius*, with Parall. of 4 m. 30 sec. and the computed distance from the Earths surface is ————— $\frac{1}{2}$ semid.
11. And upon the observations of *Munocius* and *Gemma*, with Parall. of 55 m. and the distance from the centre is rendred ————— 13 semid.
12. And

12. And upon the observations of *Munofius* and *Ursinus* with Parall. of 1 gr. 36 m. and the distance from the centre cometh forth lesse than $\frac{1}{4}$ 7 semid.

These are twelve indagations made by the Author at his election, amongst many which, as he saith, might be made by combining the observations of these thirteen observators. The which twelve we may believe to be the most favourable to prove his intention.

SAGR. I would know whether amongst the so many other indagations pretermitted by the Author, there were not some that made against him; that is, from which calculating one might find the new star to have been above the Moon, as at the very first sight I think we may reasonably question; in regard I see these already produced to be so different from one another, that some of them give me the distance of the said star from the Earth, 4, 6, 10, 100, a thousand, and an hundred thousand times bigger one than another; so that I may well suspect that amongst those that he did not calculate, there was some one in favour of the adverse party. And I guesse this to be the more probable, for that I cannot conceive that those Astronomers the observators could want the knowledg and practice of these computations, which I think do not depend upon the abstrusest things in the World. And indeed it will seem to me a thing more than miraculous, if whilst in these twelve investigations onely, there are some that make the star to be distant from the Earth but a few miles, and others that make it to be but a very small matter below the Moon, there are none to be found that in favour of the contrary part do make it so much as twenty yards above the Lunar Orb. And that which shall be yet again more extravagant, that all those Astronomers should have been so blind as not to have discovered that their so apparent mistake.

SALV. Begin now to prepare your ears to hear with infinite admiration to what excesses of confidence of ones own authority and others folly, the desire of contradicting and shewing ones self wiser than others, transports a man. Amongst the indagations omitted by the Author, there are such to be found as make the new star not onely above the Moon, but above the fixed stars also. And these are not a few, but the greater part, as you shall see in this other paper, where I have set them down.

SAGR. But what saith the Author to these? It may be he did not think of them?

SALV. He hath thought of them but too much: but saith, that the observations upon which the calculations make the star to be infinitely remote, are erroneous; and that they cannot be combined to one another.

K k

SIMP.

SIMP. But this seemeth to me a very lame evasion; for the adverse party may with as much reason reply, that those are erroneous wherewith he collecteth the star to have been in the Elementary Region.

SALV. Oh *Simplicius*, if I could but make you comprehend the craft, though no great craftinesse of this Author, I should make you to wonder, and also to be angry to see how that he palliating his sagacity with the vail of the simplicity of your self, and the rest of meer Philosophers, would insinuate himself into your good opinion, by tickling your ears, and swelling your ambition, pretending to have convinced and silenced these petty Astronomers, who went about to assault the impregnable inalterability of the *Peripatetic* Heaven, and which is more, to have foild and conquered them with their own arms. I will try with all my ability to do the same; and in the mean time let *Sagredus* take it in good part, if *Simplicius* and I try his patience, perhaps a little too much, whilst that with a superfluous circumlocution (superfluous I say to his most nimble apprehension) I go about to make out a thing, which it is not convenient should be hid and unknown unto him.

SAGR. I shall not onely without wearinesse, but also with much delight hearken to your discourses; and so ought all *Peripatetic* Philosophers, to the end they may know how much they are obliged to this their Protector.

SALV. Tell me, *Simplicius*, whether you do well comprehend, how, the new star being placed in the meridian circle yonder towards the North, the same to one that from the South should go towards the North, would seem to rise higher and higher above the Horizon, as much as the Pole, although it should have been scituate amongst the fixed stars; but, that in case it were considerably lower, that is nearer to the Earth, it would appear to ascend more than the said pole, and still more by how much its vicinity was greater?

SIMP. I think that I do very well conceive the same: in token whereof I will try if I can make a mathematical Scheme of it, and in this great circle [in Fig: 1. of this Dialogue.] I will marke the pole P; and in these two lower circles I will note two stars beheld from one place on the Earth, which let be A; and let the two stars be these B and C, beheld in the same line ABC, which line I prolong till it meet with a fixed star in D. And then walking along the Earth, till I come to the term E, the two stars will appear to me separated from the fixed star D, and advanced neerer to the pole P, and the lower star B more, which will appear to me in G, and the star C lesse, which will appear to me in F, but the fixed star D will have kept the same distance from the Pole.

SALV.

SALV. I see that you understand the businesse very well. I believe that you do likewise comprehend, that, in regard the star B is lower than C, the angle which is made by the rayes of the sight, which departing from the two places A and E, meet in C, to wit, this angle A C E, is more narrow, or if we will say more acute than the angle constituted in B, by the rayes A B and E B.

SIMP. This I likewise understand very well.

SALV. And also, the Earth being very little and almost insensible, in respect of the Firmament (or Starry Sphere;) and consequently the space A E, paced on the Earth, being very small in comparison of the immense length of the lines E G and E F, passing from the Earth unto the Firmament, you thereby collect that the star C might rise and ascend so much and so much above the Earth; that the angle therein made by the rayes which depart from the said stationary points A and E, might become most acute, and as it were absolutely null and insensible.

SIMP. And this also is most manifest to sense.

SALV. Now you know *Simplicius* that Astronomers and Mathematicians have found infallible rules by way of Geometry and Arithmetick, to be able by help of the quantity of these angles B and C, and of their differences, with the additional knowledge of the distance of the two places A and E, to find to a foot the remoteness of sublime bodies; provided alwayes that the aforesaid distance, and angles be exactly taken.

SIMP. So that if the Rules dependent on Geometry and Astronomy be true, all the fallacies and errors that might be met with in attempting to investigate those altitudes of new Stars or Comets, or other things must of necessity depend on the distance A E, and on the angles B and C, not well measured. And thus all those differences which are found in these twelve workings depend, not on the defects of the rules of the Calculations, but on the errors committed in finding out those angles, and those distances, by means of the Instrumental Observations.

SALV. True; and of this there is no doubt to be made. Now it is necessary that you observe intensely, how in removing the Star from B to C, whereupon the angle alwayes grows more acute, the ray E B G goeth farther and farther off from the ray A B D in the part beneath the angle, as you may see in the line E C F, whose inferiour part E C is more remote from the part A C, than is the part E B, but it can never happen, that by any whatsoever immense recession, the lines A D and E F should totally sever from each other, they being finally to go and conjoyn in the Star: and only this may be said, that they would separate, and reduce themselves to parallels, if so be the recession should be infinite, which

case is not to be supposed. But because (observe well) the distance of the Firmament, in relation to the smallness of the Earth, as hath been said, is to be accounted, as if it were infinite; therefore the angle contained betwixt the two rayes, that being drawn from the points A and E, go to determine in a fixed Star, is esteemed nothing, and those rayes held to be two parallel lines; and therefore it is concluded, that then only may the New Star be affirmed to have been in the Firmament, when from the collating of the Observations made in divers places, the said angle is, by calculation, gathered to be insensible, and the lines, as it were, parallels. But if the angle be of a considerable quantity, the New Star must of necessity be lower than those fixed; and also than the Moon, in case the angle A B E should be greater than that which would be made in the Moons centre.

SIMP. Then the remoteness of the Moon is not so great, that a like angle should be * insensible in her?

SALV. No Sir; nay it is sensible, not only in the Moon, but in the Sun also.

SIMP. But if this be so, it's possible that the said angle may be observed in the New Star, without necessitating it to be inferior to the Sun, as well as to the Moon.

SALV. This may very well be, yea, and is in the present case, as you shall see in due place; that is, when I shall have made plain the way, in such manner that you also, though not very perfect in *Astronomical* calculations, may clearly see, and, as it were, with your hands feel how that this Authour had it more in his eye to write in complacency of the *Peripateticks*, by palliating and disguising sundry things, than to establish the truth, by producing them with naked sincerity: therefore let us proceed forwards. By the things hitherto spoken, I suppose that you comprehend very well how that the distance of the new Star can never be made so immense, that the angle so often named shall wholly disappear, and that the two rayes of the Observers at the places A and E, shall become altogether parallels: and you may consequently comprehend to the full, that if the calculations should collect from the observations, that that angle was totally null, or that the lines were truly parallels, we should be certain that the observations were at least in some small particular erroneous: But, if the calculations should give us the said lines to be separated not only to equidistance, that is, so as to be parallel, but to have past beyond that terme, and to be dilated more above than below, then must it be resolutely concluded, that the observations were made with lesse accuratenesse, and in a word, to be erroneous; as leading us to a manifest impossibility. In the next place, you must believe me, and suppose it for true, that two right lines which

which depart from two points marked upon another right line, are then wider above than below, when the angles included between them upon that right line are greater than two right angles; and if these angles should be equal to two right angles, the lines would be parallels; but if they were less than two right angles, the lines would be concurrent, and being continued out would undoubtedly intersect the triangle.

SIMP. Without taking it upon trust from you, I know the same; and am not so very naked of *Geometry*, as not to know a Proposition, which I have had occasion of reading very often in *Aristotle*, that is, that the three angles of all triangles are equal to two right angles: so that if I take in my Figure the triangle ABE, it being supposed that the line EA is right; I very well conceive, that its three angles A, E, B, are equal to two right angles; and that consequently the two angles E and A are less than two right angles, so much as is the angle B. Whereupon widening the lines AB and EB (still keeping them from moving out of the points A and E) untill that the angle contained by them towards the parts B, disappear, the two angles beneath shall be equal to two right angles, and those lines shall be reduced to parallels: and if one should proceed to enlarge them yet more, the angles at the points E and A would become greater than two right angles.

SALV. You are an *Archimedes*, and have freed me from the expence of more words in declaring to you, that whensoever the calculations make the two angles A and E to be greater than two right angles, the observations without more adoe will prove erroneous. This is that which I had a desire that you should perfectly understand, and which I doubted that I was not able so to make out, as that a meer *Peripatetick* Philosopher might attain to the certain knowledge thereof. Now let us go on to what remains. And re-assuming that which even now you granted me, namely, that the new star could not possibly be in many places, but in one alone, when ever the supputations made upon the observations of these Astronomers do not assign it the same place, its necessary that it be an error in the observations, that is, either in taking the altitudes of the pole, or in taking the elevations of the star, or in the one or other working. Now for that in the many workings made with the combinations two by two, there are very few of the observations that do agree to place the star in the same situation; therefore these few onely may happily be the non-erroneous, but the others are all absolutely false.

SAGR. It will be necessary then to give more credit to these few alone, than to all the rest together, and because you say, that these which accord are very few, and I amongst these 12, do find two that so accord, which both make the distance of the
star

star from the centre of the Earth 4 semidiameters, which are these, the fifth and sixth, therefore it is more probable that the new star was elementary, than celestial.

SALV. You mistake the point; for if you note well it was not written, that the distance was exactly 4 semidiameters, but about 4 semidiameters; and yet you shall see that those two distances differed from each other many hundreds of miles. Here they are; you see that this fifth, which is 13389 *Italian miles*, exceeds the sixth, which is 13100 miles, by almost 300 miles.

SAGR. Which then are those few that agree in placing the star in the same situation?

SALV. They are, to the disgrace of this Author five workings, which all place it in the firmament, as you shall see in this note, where I have set down many other combinations. But I will grant the Author more than peradventure he would demand of me, which is in sum, that in each combination of the observations there is some error; which I believe to be absolutely necessary; for the observations being four in number that serve for one working, that is, two different altitudes of the Pole, and two different elevations of the star, made by different observers, in different places, with different instruments, who ever hath any small knowledge of this art, will say, that amongst all the four, it is impossible but there will be some error; and especially since we see that in taking but one only altitude of the Pole, with the same instrument, in the same place, by the same observer, that hath repeated the observation a thousand times, there will still be a titubation of one, or sometimes of many minutes, as in this same book you may see in several places. These things presupposed, I ask you *Simplicius* whether you believe that this Authour held these thirteen observers for wise, understanding and expert men in using those instruments, or else for inexpert, and bunglers?

SIMP. It must needs be that he esteemed them very acute and intelligent; for if he had thought them unskilful in the business, he might have omitted his sixth book as inconclusive, as being founded upon suppositions very erroneous; and might take us for excessively simple, if he should think he could with their inexpertness persuade us to believe a false position of his for truth.

SALV. Therefore these observers being such, and that yet notwithstanding they did erre, and so consequently needed correction, that so one might from their observations infer the best hints that may be; it is convenient that we apply unto them the least and neereft emendations and corrections that may be; so that they do but suffice to reduce the observations from impossibility to possibility; so as *v. gr.* if one may but correct a manifest error, and an apparent impossibility of one of their observations

Astronomical Instruments are very subject to error.

variations by the addition or subtraction of two or three minutes, and with that amendment to reduce it to possibility, a man ought not to essay to adjust it by the addition or subtraction of fifteen, twenty, or fifty.

SIMP. I think the Authour would not deny this: for granting that they are expert and judicious men, it ought to be thought that they did rather erre little than much.

SALV. Observe again; The places where the new Star is placed, are some of them manifestly impossible, and others possible. Absolutely impossible it is, that it should be an infinite space superior to the fixed Stars, for there is no such place in the world; and if there were, the Star there scituate would have been imperceptible to us: it is also impossible that it should go creeping along the superficies of the Earth; and much lesse that it should be within the said Terrestrial Globe. Places possible are these that be in controversie, it not interfering vvith our understanding, that a visible object in the likenesse of a Star might be aswell above the Moon, as below it. Now whilst one goeth about to compute by the way of Observations and Calculations made with the utmost certainty that humane diligence can attain unto what its place was, it is found that the greatest part of those Calculations make it more than infinitely superior to the Firmament, others make it very neer to the surface of the Earth, and some also under the same; and of the rest, which place it in situations not impossible, none of them agree with each other; insomuch that it must be confessed, that all those observations are necessarily false; so that if we would nevertheless collect some fruit from so many laborious calculations, we must have recourse to the corrections, amending all the observations.

SIMP. But the Authour will say, that of the observations that assign to the Star impossible places, there ought no account to be made, as being extreemly erroneous and false; and those onely ought to be accepted, that constitute it in places not impossible: and amongst these a man ought to seek, by help of the most probable, and most numerous concurrences, not if the particular and exact situation, that is, its true distance from the centre of the Earth, at least, whether it was amongst the Elements, or else amongst the Cœlestial bodies.

SALV. The discourse which you now make, is the self same that the Author made, in favour of his cause, but with too unreasonable a disadvantage to his adversaries; and this is that principal point that hath made me excessively to wonder at the too great confidence that he expressed to have, no less of his own authority, than of the blindness and inadvertency of the Astronomers; in favour of whom I will speak, and you shall answer for the Author.

And

And first, I ask you, whether the Astronomers, in observing with their Instruments, and seeking *v. gr.* how great the elevation of a Star is above the Horizon, may deviate from the truth, as well in making it too great, as too little; that is, may erroneously compute, that it is sometime higher than the truth, and sometimes lower; or else whether the error must needs be alwayes of one kinde, to wit, that erring they alwayes make it too much, and never too little, or alwayes too little, and never too much?

SIMP. I doubt not, but that it is as easie to commit an error the one way, as the other.

SALV. I believe the Author would answer the same. Now of these two kinds of errors, which are contraries, and into which the observators of the new star may equally have fallen, applied to calculations, one sort will make the star higher, and the other lower than really it is. And because we have already agreed, that all the observations are false; upon what ground would this Author have us to accept those for most congruous with the truth, that shew the star to have been near at hand, than the others that shew it excessively remote?

SIMP. By what I have, as yet, collected of the Authors mind, I see not that he doth refuse those observations, and indagations that might make the star more remote than the Moon, and also than the Sun, but only those that make it remote (as you your self have said) more than an infinite distance; the which distance, because you also do refuse it as impossible, he also passeth over, as being convicted of infinite falshood; as also those observations are of impossibility. Methinks, therefore, that if you would convince the Author, you ought to produce supputations, more exact, or more in number, or of more diligent observers, which constitute the star in such and such a distance above the Moon, or above the Sun, and to be brief, in a place possible for it to be in, like as he produceth these twelve, which all place the star beneath the Moon in places that have a being in the world, and where it is possible for it to be.

SALV. But *Simplicius* yours and the Authors Equivocation lyeth in this, yours in one respect, and the Authors in another; I discover by your speech that you have formed a conceit to your self, that the exorbitancies that are committed in the establishing the distance of the Star do encrease successively, according to the proportion of the errors that are made by the Instrument, in taking the observations, and that by conversion, from the greatness of the exorbitancies, may be argued the greatnesse of the error; and that therefore hearing it to be infered from such an observation, that the distance of the star is infinite, it is necessary, that the error in observing was infinite, and therefore not to be amended,

ed, and as such to be refused; but the business doth not succeed in that manner, my *Simplicius*, and I excuse you for not having comprehended the matter as it is, in regard of your small experience in such affairs; but yet cannot I under that cloak palliate the error of the Author, who dissembling the knowledge of this which he did persuade himself that we in good earnest did not understand, hath hoped to make use of our ignorance, to gain the better credit to his Doctrine, among the multitude of illiterate men. Therefore for an advertisement to those who are more credulous then intelligent, and to recover you from error, know that its possible (and that for the most part it will come to passe) that an observation, that giveth you the star *v. gr.* at the distance of *Saturn*, by the addition or subtraction of but one sole minute from the elevation taken with the instrument, shall make it to become infinitely distant; and therefore of possible, impossible, and by conversion, those calculations which being grounded upon those observations, make the star infinitely remote, may possibly oftentimes with the addition or subtraction of one sole minute, reduce it to a possible situation: and this which I say of a minute, may also happen in the correction of half a minute, a sixth part, and less. Now fix it well in your mind, that in the highest distances, that is *v. g.* the height of *Saturn*, or that of the fixed Stars, very small errors made by the Observer, with the instrument, render the situation determinate and possible, infinite & impossible. This doth not so even in the sublunary distances, and near the earth, where it may happen that the observation by which the Star is collected to be remote *v. g.* 4. Semidiameters terrestrial, may encrease or diminish, not onely one minute but ten, and an hundred, and many more, without being rendered by the calculation either infinitely remote, or so much as superior to the Moon. You may hence comprehend that the greatness of the error (to so speak) instrumental, are not to be valued by the event of the calculation, but by the quantity it self of degrees and minutes numbred upon the instrument; and these observations are to be called more just or less erroneous, which with the addition or subtraction of fewer minutes, restore the star to a possible situation; and amongst the possible places, the true one may be believed to have been that, about which a greater number of distances concur upon calculating the more exact observations.

SIMP. I do not very well apprehend this which you say: nor can I of my self conceive how it can be, that in greater distances, greater exorbitancies can arise from the error of one minute only, than in the smaller from ten or an hundred; and therefore would gladly understand the same.

SALV. You shall see it, if not Theorically, yet at least Practically,

Ll

cally, by this short assumption, that I have made of all the combinations, and of part of the workings pretermitted by the Author, which I have calculated upon this same paper.

SAGR. You must then from yesterday, till now, which yet is not above eighteen hours, have done nothing but compute, without taking either food or sleep.

SALV. I have refreshed my self both those wayes; but truth is, make these supputations with great brevity; and, if I may speak the truth, I have much admired, that this Author goeth so farre about, and introduceth so many computations no wise necessary to the question in dispute. And for a full knowledge of this, and also to the end it may soon be seen, how that from the observations of the Astronomers; whereof this Author makes use, it is more probably gathered, that the new star might have been above the Moon, and also above all the Planets, yea amongst the fixed stars, and yet higher still than they, I have transcribed upon this paper all the observations set down by the said Authour, which were made by thirteen Astronomers, wherein are noted the Polar altitude, and the altitudes of the star in the meridian, aswell the lesser under the Pole, as the greater and higher, and they are these.

Tycho.

	gr.	m.	
Altitude of the Pole	55	58	
Altitude of the Star	84	00	the greatest.
	27	57	the least.

And these are, according to the first paper: but according to the second, the greatest is ———— 27 45

Hainzelius.

	gr.	m.	sec.
Altitude of the Pole	48	22	
Altitude of the Star	76	34	
	76	33	45
	76	35	
	20	09	40
	20	09	30
	20	09	20

Pencernus

DIALOGUE. III.

267

Pencerus and Sculerus.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	51	54
Altitude of the Star	79	56
	23	33

Landgravius.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	51	18
Altitude of the Star	79	30

Camerarius.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	52	24
Altitude of the Star	80	30
	80	27
	80	26
	24	28
	24	20
	24	17

Hagecius.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	48	22
Altitude of the Star	20	15

Manrolycus.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	38	30
Altitude of the Star	62	00

Munocius.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	39	30
Altitude of the star	67	30
	11	30

Ursinus.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	49	24
Altitude of the star	79	00
	22	00

Reinholdus.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	51	18
Altitude of the star	79	30
	23	02

Buchius.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	51	10
Altitude of the star	79	20
	22	40

Gemma.

	<i>gr.</i>	<i>m.</i>
Altitude of the pole	50	50
Altitude of the star	79	45

L 1 2

Now

Now to ſee my whole proceeding, we may begin from theſe calculations, which are four, omitted by the Author, perhaps be-
 cauſe they make againſt him, in regard they place the ſtar above
 the moon by many ſemidiameters of the Earth. The firſt of
 which is this, computed upon the obſervations of the Landgrave of
Haffia, and *Tycho*; which are, even by the Authors confeſſion,
 two of the moſt exact obſervers: and in this firſt, I will declare
 the order that I hold in the working; which ſhall ſerve for all the
 reſt, in that they are all made by the ſame rule, not varying in any
 thing, ſave in the quantity of the given ſummæ, that is, in the
 number of the degrees of the Poles altitude, and of the new Stars
 elevation above the Horizon, the diſtance of which from the cen-
 tre of the Earth, in proportion to the ſemidiameter of the terre-
 ſtrial Globe is ſought, touching which it nothing imports in this
 caſe, to know how many miles that ſemidiameter containeth;
 whereupon the reſolving that, and the diſtance of places where
 the obſervations were made, as this Author doth, is but time and
 labour loſt; nor do I know why he hath made the ſame, and eſpe-
 cially why at the laſt he goeth about to reduce the miles found, in-
 to ſemidiameters of the Terreſtrial Globe.

SIMP. Perhaps he doth this to finde with ſuch ſmall meaſures,
 and with their fractions the diſtance of the Star terminated to three
 or four inches; for we that do not underſtand your rules of Arith-
 metick, are ſtupified in hearing your concluſions; as for inſtance,
 whiſt we read; Therefore the new Star or Comet was diſtant
 from the Earths centre three hundred ſeventy and three thouſand
 eight hundred and ſeven miles; and moreover, two hundred and
 eleven, four thouſand ninety ſevenths $373807\frac{11}{1000}$, and upon theſe
 preſiſe punctualities, wherein you take notice of ſuch ſmall mar-
 ters, we do conceive it to be impoſſible, that you, who in our cal-
 culations keep an account of an inch, can at the cloſe deceive us ſo
 much as an hundred miles.

SALV. This your reaſon and excuſe would paſſe for currant,
 if in a diſtance of thouſands of miles, a yard over or under were
 of any great moment, and if the ſuppoſitions that we take for
 true, were ſo certain, as that they could aſſure us of producing an
 indubitable truth in the concluſion; but here you ſee in the twelve
 workings of the Author, the diſtances of the Star, which from
 them one may conclude to have been different from each other,
 (and therefore wide of the truth) for many hundreds and thou-
 ſands of miles: now whiſt that I am more than certain, that that
 which I ſeek muſt needs differ from the truth by hundreds of miles,
 to what purpſe is it to be ſo curious in our calculations, for fear
 of miſſing the quantity of an inch? But let us proceed, at laſt,
 to the working, which I reſolve in this manner. *Tycho*, as may be
 ſeen

seen in that same note observed the star in the polar altitude of 55 degrees and 58 *mi. pri.* And the polar altitude of the *Landgrave* was 51 degrees and 18 *mi. pri.* The altitude of the star in the Meridian taken by *Tycho* was 27 degrees 45 *mi. pri.* The *Landgrave* found its altitude 23 degrees 3 *mi. pri.* The which altitudes are these noted here, as you see.

	gr.	m.	gr.	m.
<i>Tycho</i> Pole	55	58	* 27	45
<i>Landgr.</i> Pole	51	18	* 23	3

This done, subtract the lesse from the greater, and there remains these differences here underneath.

	gr.	m.
	4	40
	4	42
Parall.		2

Where the difference of the poles altitudes 4 gr. 4 *mi. pr.* is lesse than the difference of the altitudes of the Star 4 gr. 42 *mi. pr.* and therefore we have the difference of parallaxes, 0 gr. 2 *mi. pri.* These things being found, take the Authours own figure [Fig. 2.] in which the point B is the station of the *Landgrave*, D the station of *Tycho*, C the place of the star, A the centre of the Earth, ABE the vertical line of the *Landgrave*, ADF

	gr.	m.	
Ang. BAD	4	40	Its chord 8142 of those parts, whereof the semid. AB is an 100000.
BDF	92	20	
BDC	154	45 2	Sines 42657
BCD	0	2 5	58

58	42657	8142
	8142	
	85314	
	170628	
	42657	
	341256	
	59	
58	3473	13294
	571	
	5	

of *Tycho*, and the angle B C D the difference of Parallaxes. And be-

because the angle BAD , contained between the vertical lines, is equal to the difference of the Polar altitudes, it shall be $4^{\text{gr.}} 40^{\text{m.}}$ which I note here apart; and I finde the chord of it by the Table of Arches and Chords, and set it down neer unto it, which is 8142 parts, of which the semidiameter AB is 100000 . Next, I finde the angle BDC with ease, for the half of the angle BAD , which is $2^{\text{gr.}} 20^{\text{m.}}$ added to a right angle, giveth the angle $BD F$ $92^{\text{gr.}} 20^{\text{m.}}$ to which adding the angle $CD F$, which is the distance from the vertical point of the greatest altitude of the Star, which here is $62^{\text{gr.}} 15^{\text{m.}}$ it giveth us the quantity of the angle BDC , $154^{\text{grad.}} 45^{\text{min.}}$ the which I set down together with its Sine, taken out of the Table, which is 42657 , and under this I note the angle of the Parallax BCD $0^{\text{gr.}} 2^{\text{m.}}$ with its Sine 58 . And because in the Triangle BCD , the side DB is to the side BC ; as the sine of the opposite angle BCD , to the sine of the opposite angle BDC : therefore, if the line BD were 58 . BC would be 42657 . And because the Chord DB is 8142 . of those parts whereof the semidiameter BA is 100000 . and we seek to know how many of those parts is BC ; therefore we will say, by the Golden Rule, if when BD is 58 . BC is 42657 . in case the said DB were 8142 . how much would BC be? I multiply the second term by the third, and the product is 347313294 . which ought to be divided by the first, namely, by 58 . and the quotient shall be the number of the parts of the line BC , whereof the semidiameter AB is 100000 . And to know how many semidiameters BA , the said line BC doth contain, it will be necessary anew to divide the said quotient so found by 100000 . and we shall have the number of semidiameters contained in BC . Now the number 347313294 . divided by 58 . giveth $5988160\frac{1}{2}$. as here you may see.

$$\begin{array}{r}
 5988160\frac{1}{2} \\
 58 \overline{) 347313294} \\
 \underline{5717941} \\
 543
 \end{array}$$

And this divided by 100000 . the product is $59\frac{88160\frac{1}{2}}{100000}$

$$1 \overline{) 00000} \mid 59 \mid 88160.$$

But we may much abbreviate the operation, dividing the first quotient found, that is, 347313294 . by the product of the multiplication of the two numbers 58 . and 100000 . that is,

59
58'00000 | 3473 | 13294
57'
5

And this way also there will come forth 59

And so many semidiameters are contained in the line B C, to which one being added for the line A B, we shall have little lesse than 61. semidiameters for the two lines A B C; and therefore the right distance from the centre A, to the Star C, shall be more than 60. semidiameters, and therefore it is superiour to the Moon, according to *Ptolomy*, more than 27. semidiameters, and according to *Copernicus*, more than 8. supposing that the distance of the Moon from the centre of the Earth by *Copernicus* his account is what the Author maketh it, 52 semidiameters. With this same working, I find by the observations of *Camerarius*, and of *Munofius*, that the Star was situate in that same distance, to wit, somewhat more than 60. semidiameters. These are the observations, and these following next after them the calculations.

	gr.	m.		gr.	m.
Altitude of { <i>Camerar.</i>	52	24	Altitude of {	24	28
the Pole { <i>Munof.</i>	39	30	the Star {	11	30
Differences of the {			Differences {	12	58
Polar Altitudes {	12	54	of the alt. of *	12	54

Difference of Parallaxes 00 04. ang. BCD.

	gr.	m.	
{ BAD	12	54	and its chord or subtense 22466.
{ BDC	161	59	{ Sines { 30930
{ BCD	00	04	{ 116

The Golden Rule.

	22466	
116	30930	22466
	673980	
	202194	
	67398	
116	59	Distance B C 59. and
	6948	almost 60. semidiameters.
	1144	
	10	

The

G. GALILEUS, *his Systeme.*

The next working is made upon two observations of *Tycho*, and of *Munofius*, from which the Star is calculated to be distant from the Centre of the Earth 478 Semidiameters and more.

		gr. m.			gr. m.
Altitudes	{	<i>Tycho</i> . 55 58	Altitude	{	84 00
of the Pole.		<i>Munof</i> . 39 30	of the Star.		67 30
<hr/>					
Differences of the	{	16 28	Differ. of the	{	16 30
Polar Altitudes.			Alt. of the *		16 28
<hr/>					
Difference of Parallax.			0 2 and ang. BCD		

		gr. m.			
Angles	{	<i>BAD</i> . 16 28	its chord	28640	
	{	<i>BDC</i> . 104 14	{ Sines	96930	
	{	<i>BCD</i> . 0 2		58	

The Golden Rule.

58 96930 28640
28640

3877200
58 58 58
77544
89386

478
58 27760 75200
4506
53

These workings following make the Star remote from the Centre, more than 358 Semidiameters.

		gr. m.			gr. m.		
Altitudes	{	<i>Pencernus</i> 51 54	Altitude	{	79 56		
of the Pole.		<i>Munofius</i> 39 30	of the *		47 30		
		12 24			12 26		
					12 24		
					0 2		

		gr. m.			
Angles	{	<i>BAD</i> . 12 24	its chord	21600	
	{	<i>BDC</i> . 106 16	{ Sines	95996	
	{	<i>BCD</i> . 0 2		58	

The

The Golden Rule.

58 — 95996 — 21600
21600

57597600
95996
191992

357
58 | 20735 | 13600
3339
42

From this other working the star is found to be distant from the centre more than 716. semidiameters.

		gr.	m.			gr.	m.	sec.
Altitudes of the Pole	{ Landgr.	51	18	Altitude of the Star	{	79	30	00
		Hainzel.	48			22	76	33
			2			56		
						2	56	15
						2	56	
						0	00	15

		gr.	m.	sec.		
Angles	{ BAD	2	56	00	Sines	5120
	{ BDC	101	58	00		97845
	{ BCD	0	00	15		7

The Golden Rule.

7 — 97845 — 5120
5120

1956900
57845
489225

715
7 | 5009 | 66400
4

These as you see are five workings which place the star very much above the Moon. And here I desire you to consider upon that particular, which even now I told you, namely, that in great
M m di-

distances, the mutations, or if you please corrections, of a very few minutes, removereth the star a very great way farther off. As for example, in the first of these workings, where the calculation made the star 60. semidiameters remote from the centre, with the Parallax of 2. minutes; he that would maintain that it was in the Firmament, is to correct in the observations but onely two minutes, nay lesse, for then the Parallax ceaseth, or becommeth so small, that it removereth the star to an immense distance, which by all is received to be the Firmament. In the second indagation, or working, the correction of lesse than 4 *m.* *prim.* doth the same. In the third, and fourth, like as in the first, two minutes onely mount the star even above the Firmament. In the last preceding, a quarter of a minute, that is 15. seconds, gives us the same. But it doth not so occur in the sublunary altitudes; for if you fancy to your self what distance you most like, and go about to correct the workings made by the Authour, and adjust them so as that they all answer in the same determinate distance, you will find how much greater corrections they do require.

SAGR. It cannot but help us in our fuller understanding of things, to see some examples of this which you speak of.

SALV. Do you assign any whatsoever determinate sublunary distance at pleasure in which to constitute the star, for with small ado we may asertain our selves whether corrections like to these, which we see do suffice to reduce it amongst the fixed stars, will reduce it to the place by you assigned.

SAGR. To take a distance that may favour the Authour, we will suppose it to be that which is the greatest of all those found by him in his 12 workings; for whilst it is in controversie between him and Astronomers, and that they affirm the star to have been superiour to the Moon, and he that it was inferiour, very small space that he proveth it to have been lower, giveth him the victory.

SALV. Let us therefore take the seventh working wrought upon the observations of *Tycho* and *Thaddæus Hagecius*, by which the Authour found the star to have been distant from the centre 32. semidiameters, which situation is most favourable to his purpose; and to give him all advantages, let us moreover place it in the distance most disavouring the Astronomers, which is to situate it above the Firmament. That therefore being supposed, let us seek in the next place what corrections it would be necessary to apply to his other 11 workings. And let us begin at the first calculated upon the observations of *Hainzelins* and *Manroice*; in which the Authour findeth the distance from the centre about 3. semidiameters with the Parallax of 4 gr. 42 *m.* 30. *sec.* Let us

us see whether by withdrawing it 20. minutes onely, it will rise to the height of 32. semidiameters: See the short and true operation. Multiply the sine of the angle B D C, by the sine of the

		gr.	m.		gr.	m.	sec.
Hainzelius	Pole	48	32	*	76	34	30
Maurolicus	Pole	38	30	*	62	00	00
		9	52		14	34	30
					9	52	00
	Parallax	4	42		30		

Angles		gr.	m.	sec.		
	∠BAD	9	52	00	Chord	17200
	∠BDC	108	21	30	Sine	94910
	∠BCD	0	20	00	Sine	582

94910

17200

18982000

66437

9491

28

582 | 16324 | 52000

4688

2

chord B D, and divide the product, the five last figures being cut off by the sine of the Parallax, and the quotient will be 28. semidiameters, and an half, so that though you make a correction of 4 gr. 22 min. 30 sec. taken from 4 gr. 42 min. 30 sec. it shall not elevate the star to the altitude of 32. semidiameters, which correction for *Simplicius* his understanding it, is of 262. minutes, and an half.

In the second operation made upon the observations of *Hainzelius*, and *Sculerns*, with the Parallax of 0. gr. 8 min. 30 sec. the star is found in the height of 25. semidiameters or thereabouts, as may be seen in the subsequent working.

BD	Chord	6166
BDC	} Sines	97987
BCD		247

M m 2

97987

$$\begin{array}{r}
 97987 \\
 6166 \\
 \hline
 587922 \\
 587922 \\
 97987 \\
 \hline
 587922 \\
 \hline
 24 \\
 247 \overline{) 6041} \mid 87842 \\
 \underline{1103} \\
 11
 \end{array}$$

And bringing back the Parallax 0 gr. 8 m. 30 sec. to 7 gr. 7 m. whose sine is 204, the star elevateth to 30 semidiameters or thereabouts; therefore the correction of 0 gr. 1 mi. 30 sec. doth not suffice.

$$\begin{array}{r}
 20 \\
 204 \overline{) 6041} \mid 87342 \\
 \underline{1965} \\
 12
 \end{array}$$

Now let us see what correction is requisite for the third working made upon the observations of *Hainzelius* and *Tycho*, which rendereth the star about 19 semidiameters high, with the Parallax of 10 m. *prim.* The usual angles and their sines, and chord found by the Authour, are these next following; and they remove the star (as also in the Authours working) 19 semidiameters from the centre of the Earth. It is necessary therefore for the raising of it, to diminish the Parallax according to the Rule which he likewise observeth in the ninth working. Let us therefore suppose the Parallax to be 6 m. *prim.* whose sine is 175, and the division being made, there is found likewise lesse than 31 semidiameters for the stars distance. And therefore the correction of 4 *min. prim.* is too little to serve the Authours purpose.

Angles	{BAD	7	36	Chord	13254
	{BDC	195	52	Sine	40886
	{BCD	0	10	Sine	291

13254

$$\begin{array}{r}
 13254 \\
 40886 \\
 \hline
 79524 \\
 106032 \\
 106032 \\
 53016 \\
 \hline
 18 \quad \quad \quad 30 \\
 291 \mid 5419 \mid 03044 \mid 175 \mid 5419 \\
 250 \quad \quad \quad 16 \\
 181
 \end{array}$$

Let us come to the fourth working, and the rest with the same rule, and with the chords and sines found out by the Authour himself; in this the Parallax is 14 *m. prim.* and the height found lesse than 10 semidiameters, and diminishing the Parallax from 14 *min.* to 4 *min.* yet nevertheless you see that the star doth not elevate full 31 semidiameters. Therefore 10 *min.* in 14 *min.* doth not suffice.

Angles	{	BAD Chord	8142
		BDC Sine	43235
		BCD Sine	407

$$\begin{array}{r}
 43235 \\
 8142 \\
 \hline
 86470 \\
 172940 \\
 43235 \\
 345880 \\
 \hline
 30 \\
 116 \mid 3520 \mid 19370 \\
 4
 \end{array}$$

In the fifth operation of the Authour we have the sines and the chord as you see, and the Parallax is 0 *gr.* 42 *m.* 30 *sec.* which rendereth the height of the star about 4 semidiameters; and correcting the Parallax, with reducing it from 0 *gr.* 42 *m.* 30 *sec.* to 0 *gr.* 5 *m.* onely, doth not suffice to raise it to so much as 28 semidiameters, the correction therefore of 0 *gr.* 37 *m.* 30 *sec.* is too little.

Angles	{	BAD Chord	4034
		BDC Sine	97998
		BCD	1236

97998

$$\begin{array}{r}
 97998 \\
 4034 \\
 \hline
 391992 \\
 293994 \\
 \hline
 391992 \\
 27 \\
 145 | 3953 | 23932 \\
 1058 \\
 3
 \end{array}$$

In the sixth operation the chord, the sines and Parallax are as followeth, and the star is found to be about 4. semidiameters; let us see whether it will be reduced, abating the Parallax from 8 *m.* to 1 *m.* onely; Here is the operation, and the star raised but to 27. semidiameters or thereabout; therefore the correction of 7 *m.* in 8 *m.* doth not suffice.

BD	Chord	1920
BDC	Sine	40248
BCD 8 gr.	Sine	233

$$\begin{array}{r}
 40248 \\
 1920 \\
 \hline
 804960 \\
 362232 \\
 40248 \\
 \hline
 26 \\
 29 | 772 | 76160 \\
 198
 \end{array}$$

In the eighth operation the chord, the sines, and the Parallax, as you see, are these ensuing, and hence the Authour calculates the height of the star to be 1. semidiameter and an half, with the Parallax of 43. *min.* which reduced to 1 *min.* yet notwithstanding giveth the star lesse remote than 24. semidiameters, the correction therefore of 42. *min.* is not enough.

BD	Chord	1804
BDC	Sine	36643
BCD	Sine	29

36643

$$\begin{array}{r}
 36643 \\
 1804 \\
 \hline
 146572 \\
 293144 \\
 36643 \\
 \hline
 22 \\
 29 | 661 | 03972 \\
 83 \\
 2
 \end{array}$$

Let us now see the ninth. Here is the chord, the sines and the Parallax which is 15 *m*. From whence the Authour calculates the distance of the star from the superficies of the Earth to be lesse than a * seven and fortieth part of a semidiameter, but this is an error in the calculaion, for it cometh forth truly, as we shall see here below, more than a fifth: See here the quotient is $\frac{1}{5}$, which is more than one fifth.

* Here the Latine version is erroneous, making it a fortieth part of, &c.

B D	Chord	232
B D C	Sine	39046
B C D	Sine	436

$$\begin{array}{r}
 39046 \\
 232 \\
 \hline
 78092 \\
 117138 \\
 78092 \\
 \hline
 436 | 90 | 58672
 \end{array}$$

That which the Authour presently after subjoyns in way of amending the observations, that is, that it sufficeth not to reduce the difference of Parallax, neither to a minute, nor yet to the eighth part of a minute is true. But I say, that neither will the tenth part of a minute reduce the height of the star to 32. semidiameters; for the sine of the tenth part of a minute, that is of six seconds, is 3; by which if we according to our Rule should divide 90. or we may say, if we should divide 9058672. by 300000. the quotient will be 30 $\frac{158672}{300000}$, that is little more than 30. semidiameters and an half.

The tenth giveth the altitude of the star one fifth of a semidiameter, with these angles, sines, and Parallax, that is, 4 *gr.* 30

G. GALILEUS, *his Systeme.*

30 m. which I see that being reduced from 4 gr. 30 min. to 2 min. yet neverthelesse it elevates not the star to 29. semidiameters.

BD	Chord	1746
BDC	Sine	92050
BCD 4 gr. 30 m.	Sine	7846

92050
17460

552300
36820

64435
9205

27

58 | 1607 | 19300

441

4

The eleventh rendereth the star to the Authour remote about 13. semidiameters, with the Parallax of 55. min. let us see, reducing it to 20 min. whether it will exalt the star: See here the calculation elevates it to little lesse than 33. semidiameters, the correction therefore is little lesse than 35. min. in 55. min.

BD	Chord	19748
BDC	Sine	96166
BCD 0 gr. 55 m.	Sine	1600

96166

19748

639328

384664

673162

865494

96166

32

582 | 18990 | 56168

1536

56

The twelfth with the Parallax of 1. gr. 36. min. maketh the star lesse high than 6. semidiameters, reducing the Parallax to 20 min. it carrieth the star to lesse than 30. semidiameters distance, therefore the correction of 1 gr. 16. min. sufficeth not.

BD

DIALOGUE III.

281

BD Chord 17258
 BDC Sine 96150
 BCD 1 gr. 36 m. Sine 2792

17258
 96150
 862900
 17258
 103548
 155322
 582 | 28 | 56700
 16593
 4957
 29

*These are the Corrections of the Parallaxes
 of the ten workings of the Author, to
 reduce the Star to the altitude of
 32 Semidiameters.*

gr. m. sec.		gr. m. sec.
04 22 30	in	04 42 30
00 04 00	in	00 10 00
00 10 00	in	00 14 00
00 37 00	in	00 42 30
00 07 00	in	00 18 00
00 42 00	in	00 43 00
00 14 50	in	00 15 00
04 28 00	in	04 30 00
00 35 00	in	00 55 00
01 16 00	in	01 36 00
216		296.60
540		240. 9
765		836.540

From hence we see, that to reduce the Star to 32. Semidiameters in altitude, it is requisite from the sum of the Parallaxes 836. to subtract 765. and to reduce them to 80. nor yet doth that correction suffice.

N n

Here

Here we see also, (as I have noted even now) that should the Authour consent to assign the distance of 32. Semidiameters for the true height of the Star, the correction of those his 10. workings, (I say 10. because the second being very high, is reduced to the height of 32. Semidiameters, with 2. minutes correction) so make them all to restore the said Star to that distance, would require such a reduction of Parallaxes, that amongst the whole number of subtractions they should make more than 756 *m. pr.* whereas in the 5. calculated by me, which do place the Star above the Moon, to correct them in such sort, as to constitute it in the Firmament, the correction onely of 10. minutes, and one fourth sufficeth.

Now adde to these, other 5. workings, that place the Star precisely in the Firmament, without need of any correction at all, and we shall have ten workings or indagations that agree to place it in the Firmament, with the correction onely of 5. of them (as hath been seen) but 10. *m.* and 15 *sec.* Whereas for the correction of those 10. of the Authour, to reduce them to the altitude of 32. semidiameters, there will need the emendations of 756 minutes in 836. that is, there must from the summe 836 be subtracted 756. if you would have the Star elevated to the altitude of 32. semidiameters, and yet that correction doth not fully serve.

The workings that immediately without any correction free the Star from Parallaxes, and therefore place it in the Firmament, and that also in the remotest parts of it, and in a word, as high as the Pole it self, are these 5. noted here.

	gr. m.		gr. m.
Camerar. } Polar altit.	52 24	Altit. of the Star	80 26
Pencernus }	51 54		79 56
	0 30		0 30

	gr. m.		gr. m.
Landgrav. } Polar altit.	51 18	Altit. of the Star	79 30
Hainzel. }	48 22		76 34
	2 56		2 56

	gr. m.		gr. m.
Tycho } Polar altit.	55 58	Altit. of the Star	84 00
Pencernus }	51 54		79 56
	4 4		4 4

Reinold.

	gr. m.		gr. m.
Reinhold.	{ Polar altit.	{ 51 18	{ Altit. of the Star { 79 30
Hainzel.		{ 48 22	
		2 56	2 56

	gr. m.		gr. m.
Camerar.	{ Polar altit.	{ 52 24	{ Altit. of the Star { 24 17
Hagecius		{ 48 22	
		4 2	4 2

Of the remaining combinations that might be made of the Observations of all these Astronomers, those that make the Stars sublime to an infinite distance, are many in number, namely, about 30. more than those who give the Star, by calculation, to be below the Moon; and because (as it was agreed upon between us) it is to be believed that the Observators have erred rather little than much, it is a manifest thing that the corrections to be applied to the Observations, which make the star of an infinite altitude, to reduce it lower, do sooner, and with lesser amendment place it in the Firmament, than beneath the Moon; so that all these applaud the opinion of those who put it amongst the fixed Stars. You may adde, that the corrections required for those emendations, are much lesser than those, by which the Star from an unlikely proximity may be removed to the height more favourable for this Authour, as by the foregoing examples hath been seen; amongst which impossible proximities, there are three that seem to remove the Star from the Earths centre, a lesse distance than one Semidiameter, making it, as it were, to turn round under ground, and these are those combinations, wherein the Polar altitude of one of the Observators being greater than the Polar altitude of the other, the elevation of the Star taken by the first, is lesser than the elevation of the Star taken by the latter.

The first of these is this of the Landgrave with Gemma, where the Polar altitude of the Landgrave 51 gr. 18 min. is greater than the Polar altitude of Gemma, which is 50 gr. 50 m. But the altitude of the Star of the Landgrave 79 gr. 30 min. is lesser than that of the Star, of Gemma 79 gr. 45 min.

	gr. m.		gr. m.
Landgrave	{ Polar altit.	{ 51 18	{ Altit. of the Star { 79 30
Gemma		{ 50 50	
		N n 2	The

The other two are these below.

		<i>gr. m.</i>		<i>gr. m.</i>
<i>Busebius.</i>	} Polar Altitude {	51 10	} Altit. of the Star {	79 20
<i>Gemma.</i>		50 50		79 45

<i>Reinholdus.</i>	} Polar Altitude {	51 18	} Altit. of the Star {	79 30
<i>Gemma.</i>		50 50		79 45

From what I have hitherto demonstrated, you may guesse how much this first way of finding out the distance of the Star, and proving it sublunary introduced by the Authour, maketh against himself, and how much more probably and clearly the distance thereof is collected to have been amongst the more remote fixed Stars.

SIMEI. As to this particular, I think that the inefficacy of the Authors demonstrations is very plainly discovered; But I see that all this was comprised in but a few leaves of his Book, and it may be, that some other of his Arguments are more conclusive then these first.

SALV. Rather they must needs be lesse valid, if we will take those that lead the way for a proof of the rest: For (as it is clear) the uncertainty and inconclusiveness of those, is manifestly observed to derive it self from the errors committed in the instrumental observations, upon which the Polar Altitude, and height of the Star was thought to have been justly taken, all in effect having easily erred; And yet to find the Altitude of the Pole, Astronomers have had Ages of time to apply themselves to it, at their leisure: and the Meridian Altitudes of the Star are easier to be observed, as being most terminate, and yielding the Observer some time to continue the same, in regard they change not sensibly, in a short time, as those do that are remote from the Meridian. And if this be so, as it is most certain, what credit shall we give to Calculations founded upon Observations more numerous, more difficult to be wrought, more momentary in variation, and we may add, with Instruments more incommodious and erroneous? Upon a slight perusal of the ensuing demonstrations, I see that the Computations are made upon Altitudes of the Star taken in different Vertical Circles, which are called by the Arabick name, *Azimuths*; in which observations moveable instruments are made use of, not only in the Vertical Circles, but in the Horizon also, at the same time; insomuch that it is requisite in the same moment that the altitude is taken, to have observed, in the Horizon, the distance of the Vertical

tical point in which the Star is, from the Meridian; Moreover, after a considerable interval of time, the operation must be repeated, and exact account kept of the time that passed, trusting either to Dials, or to other observations of the Stars. Such an *Olio* of Observations doth he set before you, comparing them with such another made by another observer in another place with another different instrument, and at another time; and from this the Authour seeks to collect what would have been, the Elevations of the Star, and Horizontal Latitudes happened in the time and hour of the other first observations, and upon such a coequation he in the end grounds his account. Now I refer it to you, what credit is to be given to that which is deduced from such like workings. Moreover, I doubt not in the least; but that if any one would torture himself with such tedious computations, he would find, as in those foregoing, that there were more that would favour the adverse party, than the Authour: But I think it not worth the while to take so much pains in a thing, which is not, amongst those primary ones, by us understood.

I. SAGR. I am of your Opinion in this particular: But this business being environed with so many intricacies, uncertainties, and errors, upon what confidence have so many Astronomers positively pronounced the new Star to have been so high?

SALV. Upon two sorts of observations most plain, most easie, and most certain; one only of which is more than sufficient to assure us, that it was scituate in the Firmament, or at least by a great distance superiour to the Moon. One of which is taken from the equality, or little differing inequality of its distances from the Pole; as well whilst it was in the lowest part of the Meridian; as when it was in the uppermost: The other is its having perpetually kept the same distances from certain of the fixed Stars, adjacent to it, and particularly from the eleventh of *Cassiopea*, no more remote from it than one degree and an half; from which two particulars is undoubtedly inferred, either the absolute want of Parallax, or such a smallness thereof, that it doth assure us with very expeditious Calculations of its great distance from the Earth.

SAGR. But these things, were they not known to this Author? and if he saw them, what doth he say unto them?

SALV. We are wont to say, of one that having no reply that is able to cover his fault, produceth frivolous excuses, *cerca di at-
taccarsi alle funi del cielo*; [He strives to take hold of the Cords of Heaven;] but this Authour runs, not to the Cords, but to the Spiders Web of Heaven; as you shall plainly see in our examination of these two particulars even now hinted. And first, that which sheweth us the Polar distances of the Observators one by one, I have noted down in these brief Calculations; For a full under-
stand-

standing of which, I ought first to advertise you, that when ever the new Star, or other Phænomenon is near to the earth, turning with a Diurnal motion about the Pole, it will seem to be farther off from the said Pole, whilst it is in the lower part of the Meridian, then whilst it is above, as in this Figure. [*being fig. third of this Dial.*] may be seen. In which the point T. denotes the centre of the Earth; O. the place of the Observator; the Arch VPC the Firmament; P. the Pole. The *Phænomenon*, [*or appearance*] moving along the Circle FS. is seen one while under the Pole by the Ray OFC. and another while above, according to the Ray OSD. so that the places seen in the Firmament are D. and C. but the true places in respect of the Centre T, are B. and A, equidistant from the Pole. Where it is manifest that the apparent place of the *Phænomenon* S, that is the point D, is nearer to the Pole than the other apparent place C, seen along the Line or Ray OFC, which is the first thing to be noted. In the second place you must note that the excess of the apparent inferior distance from the Pole, over and above the apparent superior distance from the said Pole, is greater than the Inferiour Parallax of the *Phænomenon*, that is, I say, that the excess of the Arch CP, (the apparent inferior distance) over and above the Arch PD, (the apparent superior distance) is greater then the Arch CA, (that is the inferior Parallax.) Which is easily proved; for the Arch CP. more exceedeth PD, then PB; PB, being bigger than PD, but PB. is equal to PA, and the excess of CP, above PA, is the arch, CA, therefore the excess of the arch CP above the arch PD, is greater than the arch CA, which is the parallax of the *Phænomenon* placed in F, which was to be demonstrated. And to give all advantages to the Author, let us suppose that the parallax of the star in F, is the whole excess of the arch CP (that is of the inferior distance from the pole) above the arch PD (the inferior distance.) I proceed in the next place to examine that which the observations of all Astronomers cited by the Authour giveth us, amongst which, there is not one that maketh not against himself and his purpose. And let us begin with these of *Buschius*, who findeth the stars distance from the pole, when it was superior, to be 28 gr. 10 m. and the inferior to be 28 gr. 30 m. so that the excess is 0 gr. 20 m. which let us take (in favour of the Author) as if it all were the parallax of the star in F, that is the angle TFO. Then the distance from the Vertex [*or Zenith*] that is the arch CV, is 67 gr. 20 m. These two things being found, prolong the line CO, and from it let fall the perpendicular TI, and let us consider the triangle TOI, of which the angle I is right angle, and the angle IOT known, as being vertical to the angle VOE, the distance of the star from the Vertex, Moreover in the triangle TIF,

TIF, which is also rectangular, there is known the angle F, taken by the parallax. Then note in some place apart the two angles IOT and IFT, and of them take the sines, which are here set down to them, as you see. And because in the triangle IOT, the sine TI is 92276. of those parts, whereof the whole sine TO is 100000; and moreover in the triangle IFT, the sine TI is 582. of those parts, whereof the whole sine TF is 100000, to find how many TF is of those parts, whereof TO is 100000; we will say by the Rule of three: If TI be 582. TF is an 100000. but if TI were 92276. how much would TF be. Let us multiply 92276. by 100000. and the product will be 9227600000. and this must be divided by 582. and the quotient will be 15854982. and so many shall there be in TF of those parts, of which there are in TO an 100000. So that if it were required to know how many lines TO, are in TF, we would divide 15854982 by 100000. and there will come forth 158. and very near an half; and so many diameters shall be the distance of the star F, from the centre T, and to abbreviate the operation, we seeing, that the product of the multiplication of 92276. by 100000, ought to be divided first by 582, and then the quotient of that division by 100000. we may without multiplying 92276. by 100000. and with one onely division of the sine 92276. by the sine 582. soon obtain the same solution; as may be seen there below; where 92276. divided by 582. giveth us the said 158½, or thereabouts. Let us bear in mind therefore, that the onely division of the sine TI, as the sine of the angle TOI by the sine TI, as the sine of the angle IFT, giveth us the distance sought TF, in so many diameters TO.

		gr.	m.	
Angles	IOT	67	20	Sines
	IFT	0	20	

TI	TF	TI	TF
582	10000	92276	0

15854982

582 | 9227600000

3407002746

49297867

325414

100000 | 158 | 54982

158

582 | 92276

34070

492

3

See

See next that which the observations of *Pencerns* giveth us, in which the inferiour distance from the Pole is 28 gr. 21 m. and the superiour 28 gr. 2 m. the difference 0 gr. 19 m. and the distance from the vertical point 66 gr. 27 m. from which particulars is gathered the stars distance from the centre almost 166 semediameters.

	gr.	m.	
Angles $\left\{ \begin{array}{l} IAC \\ IEC \end{array} \right.$	66	27	Sines $\left\{ \begin{array}{l} 91672 \\ 553 \end{array} \right.$
	0	19	
		165 ⁴⁴	
	553	91672	
		36397	
		312	
		4	

Here take what *Tycho* his observation holdeth forth to us, interpreted with greatest favour to the adversary; to wit, the inferiour distance from the pole is 28 gr. 13 m. and the superiour 28 gr. 2 m. omitting the difference which is 0 gr. 11 m. as if all were one Parallax; the distance from the vertical point 62 gr. 15 m. Behold here below the operation, and the distance of the star from the centre found to be 976²/₃ semidiameters.

	gr.	m.	
Angles $\left\{ \begin{array}{l} IAC \\ IEC \end{array} \right.$	62	15	Sines $\left\{ \begin{array}{l} 88500 \\ 320 \end{array} \right.$
	0	11	
		276 ² / ₃	
	320	88500	
		2418	
		1	

The observation of *Reinholdus*, which is the next ensuing giveth us the distance of the Star from the Centre 793. Semidiameters.

	gr.	m.	
Angles $\left\{ \begin{array}{l} IAC \\ IEC \end{array} \right.$	66	58	Sines $\left\{ \begin{array}{l} 92026 \\ 116 \end{array} \right.$
	0	4	
		793 ²¹ / ₃	
	116	92026	
		10888	
		33	

From

From the following observation of the *Landgrave*, the distance of the Star from the Centre is made to be 1057, Semidiameters.

$$\begin{array}{rcl}
 \text{Angles} \left\{ \begin{array}{l} \text{IAC} \\ \text{IEC} \end{array} \right. & \begin{array}{cc} \text{gr.} & \text{m.} \\ 66 & 57 \\ 0 & 3 \end{array} & \left. \begin{array}{l} \text{Sines} \\ \end{array} \right\} \begin{array}{l} 92012 \\ 87 \end{array} \\
 & & 1057^{\frac{11}{14}} \\
 87 & | & 92012 \\
 & & 5663 \\
 & & 5
 \end{array}$$

Two of the most favourable observations for the Authour being taken from *Camerarius*, the distance of the Star from the Centre is found to be 3143 Semidiameters.

$$\begin{array}{rcl}
 \text{Angles} \left\{ \begin{array}{l} \text{IAC} \\ \text{IEC} \end{array} \right. & \begin{array}{cc} \text{gr.} & \text{m.} \\ 65 & 43 \\ 0 & 1 \end{array} & \left. \begin{array}{l} \text{Sines} \\ \end{array} \right\} \begin{array}{l} 91152 \\ 29 \end{array} \\
 & & 3143 \\
 29 & | & 91152 \\
 & & 4295
 \end{array}$$

The Observation of *Munofius* giveth no *Parallax*, and therefore rendreth the new Star amongst the highest of the fixed. That of *Hainzelius* makes it infinitely remote, but with the correction of an half *min. prim.* placeth it amongst the fixed Stars. And the same is collected from *Orfinus*, with the correction of 12. *min. prim.* The other Astronomers have not given us the distance above and below the Pole, so that nothing can be concluded from them. By this time you see, that all the observations of all these men conspire against the Author, in placing the Star in the Heavenly and highest Regions.

SAGR. But what defence hath he for himself against so manifest contradictions?

SALV. He betakes himself to one of those weak threads which I speak of, saying that the *Parallaxes* come to be lessened by means of the refractions, which operating contrarily sublimates the *Phænomenon*, whereas the *Parallaxes* abase it. Now of what little stead this lamentable refuge is, judge by this, that in case that effect of the refractions were of such an efficacy, as that which not long time since some Astronomers have introduced, the most that they could work touching the elevating a *Phænomenon* above the Horizon

O o

more

more than truth, when it is before hand 23. or 24. Degrees high, would be the lessening its *Parallax* about 3. minutes, the which abatement is too small to pull down the Star below the Moon, and in some cases is lesse than the advantage given him by us in admitting that the excessse of the inferiour distance from the Pole above the Superiour, is all *Parallax*, the which advantage is far more clear and palpable than the effect of Refraction, of the greatnesse of which I stand in doubt, and not without reason. But besides, I demand of the Author, whether he thinks that those Astronomers; of whose observations he maketh use, had knowledge of these effects of Refractions, and considered the same, or no; if they did know and consider them, it is reasonable to think that the, kept account of them in assigning the true Elevation of the Star, making in those degrees of Altitude discovered with the Instruments, such abatements as were convenient on the account of the alterations made by the Refractions; insomuch that the distances by them delivered, were in the end those corrected and exact, and not the apparent and false ones. But if he think that those Authors made no reflection upon the said Refractions, it must be confessed, that they had in like manner erred in determining all those things which cannot be perfectly adjusted without allowance for the Refractions; amongst which things one is the precise investigation of the Polar Altitudes, which are commonly taken from the two Meridian Altitudes of some of the fixed Stars that are constantly visible, which Altitudes will come to be altered by Refraction in the same manner, just as those of the new Star; so that the Polar Altitude that is deduced from them, will prove to be defective, and to partake of the self same want which this Author assigns to the Altitudes ascribed to the new Star, to wit, both that and these will be with equal falshood placed higher than really they are. But any such error, as far as concerns our present businessse, doth no prejudice at all: For we not needing to know any more, but onely the difference between the two distances of the new Star from the Pole at such time as it was inferiour and superiour, it is evident that such distances would be the same, taking the alteration of Refraction commonly for the Star and for the Pole, or for them when commonly amended. The Authors Argument would indeed have had some strength, though very small, if he had assured us that the Altitude of the Pole had been once precisely assigned, and corrected from the error depending on refraction, from which again the Astronomers had not kept themselves in assigning the altitudes of the new Star; but he hath not ascertained us of that, nor perhaps could he have done, nor haply, (and this is more probable) was that caution wanting in the Observators.

S A G R. This argument is in my judgment sufficiently answered;

ed; therefore tell me how he dis-ingageth himself in the next place from that particular of the Stars having constantly kept the same distance from the fixed Stars circumjacent to it.

SALV. He betakes himself, in like manner, to two threads, yet more unable to uphold him than the former: one of which is likewise fastened to refraction, but so much less firmly, in that he saith, that refraction operating upon the new Star, and sublimating it higher than its true situation, maketh the seeming distances uncertain to be distinguished from the true, when compared to the circumposed fixed Stars that environ it. Nor can I sufficiently admire how he can dissemble his knowing how that the same refraction will work alike upon the new Star, as upon the antient one its neighbour, elevating both equally, so as that such a like accident altereth not the space betwixt them. His other subterfuge is yet more unhappy, and carryeth with it much of ridiculous, it being founded upon the error that may arise in the instrument's operation it self; whilst that the Observator not being able to constitute the centre of the eyes pupil in the centre of the Sextant (an Instrument employed in observing the distance between two Stars) but holding it elevated above that centre, as much as the said pupil is distant from I know not what bone of the cheek, against which the end of the Instrument resteth, there is formed in the eye an angle more acute than that which is made by the sides of the Instrument; which angle of rayes differeth also from it self, at such time as a man looketh upon Stars, not much elevated above the Horizon, and the same being afterwards placed at a great height; that angle, saith he, is made different, while the Instrument goeth ascending, the head standing still: but if in mounting the Instrument, the neck should bend backwards, and the head go rising, together with the Instrument, the angle would then continue the same. So that the Authours answer supposeth that the Observators in using the Instrument have not raised the head, as they ought to have done; a thing which hath nothing of likelihood in it. But granting that so it had been, I leave you to judge what difference can be between two acute angles of two equicrural triangles, the sides of one of which triangles are each four [Italian] Braces [i.e. about three English yards] and those of the other, four braces within the quantity of the diameter of a Pea; for the differences cannot be absolutely greater between the length of the two visive rayes, whilst the line is drawn perpendicularly from the centre of the pupil, upon the plain of the Rule of the Sextant (which line is no bigger than the breath of the thumb) and the length of the same rayes, whilst elevating the Sextant, without raising the head together with it, that same line no longer falleth perpendicularly upon the said plane, but inclineth, making the

* Treguardi.

the angle towards the circumference something acute. But wholly to free this Authour from these unhappy lies, let him know, (in regard it appears that he is not very skilful in the use of Astronomical Instruments) that in the sides of the Sextant or Quadrant there are placed two * Sights, one in the centre, and the other at the other at the opposite end, which are raised an inch or more above the plane of the Rule; and through the tops of those sights the ray of the eye is made to passe, which eye likewise is held an hands breadth or two, or it may be more, from the Instrument; so that neither the pupil, nor any bone of the cheek, nor of the whole body toucheth or stayeth it self upon the Instrument, nor much lesse is the Instrument upheld or mounted in the armes, especially if it be one of those great ones, as is usual, which weighing tens, hundreds, and also thousands of pounds, are placed upon very strong feet or frames: so that the whole objection vanisheth. These are the subterfuges of this Authour, which, though they were all of steel, would not secure him the hundredth part of a minute; and with these he conceits to make us believe, that he hath compensated that difference, which importeth more than an hundred minutes; I mean, that of the not observing a notable difference in the distances between one of the fixed stars, and the new star in any of their circulations; which, had it been neer to the Moon, it ought to have been very conspicuous to the meer sight, without any Instrument, especially comparing it with the eleventh of *Cassiopeia*, its neighbour, within 1 gr. 30 m. which ought to have varied from it more than two diameters of the moon, as the more intelligent Astronomers of those times do well note.

S. A. G. R. Methinks I see that unfortunate Husbandman, who after all his expected crops, have been beaten down and destroyed by a storm, goeth up and down with a languishing and down-cast look, gleaning up every small ear that would not suffice to keep a chicken alive one sole day.

S. A. L. V. Truly, this Authour came out too slenderly provided with armes against the assailants of the Heavens inalterability, and with too brittle a chain attempted to pull down the new star of *Cassiopeia* from the highest Regions, to these so low and elementary. And for that I think that we have sufficiently demonstrated the vast difference that is between the arguments of those Astronomers, and of this their Antagonist, it will be convenient that we leave this particular, and return to our principal matter; in which there presents it self to our consideration the annual motion commonly ascribed to the Sun, but by *Aristarchus Samius* first of all, and after by *Copernicus* taken from the Sun, and transferred upon the Earth; against which Hypothesis, methinks I see *Simplicius* to come strongly provided, and particularly with the sword and buckler

buckler of the little Treatise of *Conclusions*, or Disquisitions Mathematical, the oppugnations of which it would be good to begin to produce.

SIMP. I will, if you so please, reserve them to the last, as those that are of latest invention.

SALV. It will therefore be necessary, that in conformity to the method hitherto observed, you do orderly, one by one, propound the arguments, on the contrary, as well of *Aristotle*, as of the other ancients, which shall be my task also, that so nothing may escape our strict consideration and examination; and likewise *Sagredus*, with the vivacity of his wit, shall interpose his thoughts, as he shall finde himself inclined.

SAGR. I will do it with my wonted freedome; and your commands shall oblige you to excuse me in so doing.

SALV. The favour will challenge thanks, and not an excuse. But now let *Simplicius* begin to propose those doubts which dissuade him from believing that the Earth, in like manner, as the other planets, may move round about a fixed centre.

SIMP. The first and greatest difficulty is the repugnance and incompatibility that is between being in the centre, and being far from it; for if the Terrestrial Globe were to move in a year by the circumference of a circle, that is, under the *Zodiack*, it is impossible that it should, at the same time, be in the centre of the *Zodiack*; but that the Earth is in the said centre *Aristotle*, *Ptolomy*, and others have many wayes proved.

SALV. You very well argue, and there is no question but that one that would make the Earth to move in the circumference of a circle, must first of necessity prove, that it is not in the centre of that same circle; it now followeth, that we enquire, whether the Earth be, or be not in that centre, about which, I say, that it turneth, and you say that it is fixed; and before we speak of this, it is likewise necessary that we declare our selves, whether you and I have both the same conceit of this centre, or no. Therefore tell me, what and where is this your intended centre?

SIMP. When I speak of the centre, I mean that of the Universe, that of the World, that of the Starry Sphere.

SALV. Although I might very rationally put it in dispute, whether there be any such centre in nature, or no; being that neither you nor any one else hath ever proved, whether the World be finite and figurate, or else infinite and interminate; yet nevertheless granting you, for the present, that it is finite, and of a terminate Spherical Figure, and that thereupon it hath its centre; it will be requisite to see how credible it is that the Earth, and not rather some other body, doth possesse the said centre.

SIMP. That the world is finite, terminate, and spherical, *Aristotle*

It hath not been hitherto proved by any, whether the World be finite or infinite.

The Demonstrations of Aristotle to prove that the Universe is finite, are all nullified by denying it to be moveable.

Aristotle makes that point to be the centre of the Universe about which all the Cœlestial Spheres do revolve.

A question is put, in case that if Aristotle were forced to receive one of two propositions that make against his doctrine, which he would admit.

Aristotle proveth with an hundred demonstrations.

SALV. All which in the end are reduced to one alone, and that one to none at all; for if I deny his assumption, to wit, that the Universe is moveable, all his demonstrations come to nothing, for he onely proveth the Universe to be finite and terminate, for that it is moveable. But that we may not multiply disputes, let it be granted for once, that the World is finite, spherical, and hath its centre. And seeing that that centre and figure is argued from its mobility, it will, without doubt, be very reasonable, if from the circular motions of mundane bodies we proceed to the particular investigation of that centres proper place: Nay *Aristotle* himself hath argued and determined in the same manner, making that same to be the centre of the Universe about which all the Cœlestial Spheres revolve, and in which he beleived the Terrestrial Globe to have been placed. Now tell me *Simplicius*, if *Aristotle* should be constrained by evident experience to alter in part this his disposure and order of the Universe, and confesse himself to have been deceived in one of these two propositions, namely, either in placing the Earth in the centre, or in saying, that the Cœlestial Spheres do move about that centre, which of the two confessions think you would he choose?

SIMP. I believe, that if it should so fall out, the *Peripateticks*.

SALV. I do not ask the *Peripateticks*, I demand of *Aristotle*, for as to those, I know very well what they would reply; they, as observant and humble vassals of *Aristotle*, would deny all the experiments and all the observations in the World, nay, would also refuse to see them, that they might not be forced to acknowledge them, and would say that the World stands as *Aristotle* writeth, and not as nature will have it, for depriving them of the shield of his Authority, with what do you think they would appear in the field? Tell me therefore what you are perswaded *Aristotle* himself would do in the case.

SIMP. To tell you the truth, I know not how to resolve which of the two inconveniences is to be esteemed the lesser.

SALV. Apply not I pray you this term of inconvenience to a thing which possibly may of necessity be so. It was an inconvenience to place the Earth in the centre of the Cœlestial revolutions; but seeing you know not to which part he would incline, I esteeming him to be a man of great judgment, let us examine which of the two choices is the more rational, and that we will hold that *Aristotle* would have received. Reassuming therefore our discourse from the beginning, we suppose with the good liking of *Aristotle*, that the World (of the magnitude of which we have no sensible notice beyond the fixed stars) as being of a spherical figure;

figure; and moveth circularly, hath necessarily, and in respect of its figure a centre; and we being moreover certain, that within the starry Sphere there are many Orbs, the one within another, with their stars, which likewise do move circularly, it is in dispute whether it is most reasonable to believe and to say that these contained Orbs do move round the said centre of the World, or else about some other centre far remote from that? Tell me now *Simplicius* what you think concerning this particular.

SIMP. If we could stay upon this onely supposition, and that we were sure that we might encounter nothing else that might disturb us, I would say that it were much more reasonable to affirm that the Orb containing, and the parts contained, do all move about one common centre, than about divers.

SALV. Now if it were true that the centre of the World is the same about which the Orbs of mundane bodies, that is to say, of the Planets, move, it is most certain that it is not the Earth, but the Sun rather that is fixed in the centre of the World. So that as to this first simple and general apprehension, the middle place belongeth to the Sun; and the Earth is as far remote from the centre, as it is from that same Sun.

SIMP. But from whence do you argue that not the Earth, but the Sun is in the centre of the Planetary revolutions?

SALV. I infer the same from most evident, and therefore necessarily concludent observations, of which the most palpable to exclude the Earth from the said centre, and to place the Sun therein, are, the seeing all the Planets one while neerer and another while farther off from the Earth with so great differences, that for example, *Venus* when it is at the farthest, is six times more remote from us, than when it is neereſt, and *Mars* riseth almost eight times as high at one time as at another. See therefore whether *Aristotle* was not somewhat mistaken in thinking that it was at all times equidistant from us.

SIMP. What in the next place are the tokens that their motions are about the Sun?

SALV. It is argued in the three superiour planets *Mars*, *Jupiter*, and *Saturn*, in that we find them alwayes neereſt to the Earth when they are in opposition to the Sun, and farthest off when they are towards the conjunction, and this approximations and recession importeth thus much that *Mars* neer at hand, appeareth very neer 60 times greater than when it is remote. As to *Venus* in the next place, and to *Mercury*, we are certain that they revolve about the Sun, in that they never move far from him, and in that we see them one while above and another while below it, as the mutations of figure in *Venus* necessarily argueth. Touching the Moon it is certain, that she cannot in any way

It is more rational that the Orb containing, and the parts contained, do move all about one centre, than upon divers.

If the centre of the World be the same with that about which the planets move, the Sun and not the Earth is placed in it.

Observations from whence it is collected that the Sun and not the Earth is in the centre of the Celestial revolutions.

The mutation of figure in Venus argueth its motion to be about the Sun.

The Moon cannot separate from the Earth.

separate from the Earth, for the reasons that shall be more distinctly alledged hereafter.

SAGR. I expect that I shall hear more admirable things that depend upon this annual motion of the Earth, than were those dependant upon the diurnal revolution.

The annual motion of the Earth mixing with the motions of the other Planets produce extravagant appearances.

SALV. You do not therein erre: For as to the operation of the diurnal motion upon the Celestial bodies, it neither was, nor can be other, than to make the Universe seem to run precipitately the contrary way; but this annual motion intermixing with the particular motions of all the planets, produceth very many extravagancies, which have disarmed and non-plust all the greatest Scholars in the World. But returning to our first general apprehensions, I reply that the centre of the Celestial conversions of the five planets *Saturn, Jupiter, Mars, Venus and Mercury*, is the Sun; and shall be likewise the centre of the motion of the Earth, if we do but succeed in our attempt of placing it in Heaven. And as for the Moon, this hath a circular motion about the Earth, from which (as I said before) it can by no means alienate it self, but yet doth it not cease to go about the Sun together with the Earth in an annual motion.

SIMP. I do not as yet very well apprehend this structure, but it may be, that with making a few draughts thereof, one may better and more easily discourse concerning the same.

The Systeme of the Universe designed from the appearances.

SALV. 'Tis very true: yea for your greater satisfaction and admiration together, I desire you, that you would take the pains to draw the same; and to see that although you think you do not apprehend it, yet you very perfectly understand it; And onely by answering to my interrogations you shall designe it punctually. Take therefore a sheet of paper and Compasses; And let this white paper be the immense expansion of the Universe; in which you are to distribute and dispose its parts in order, according as reason shall direct you. And first, in regard that without my instruction you verily believe that the Earth is placed in this Universe, therefore note a point at pleasure, about which you intend it to be placed, and mark it with some characters.

SIMP. Let this mark A be the place of the Terrestrial Globe.

SALV. Very well. I know secondly, that you understand perfectly that the said Earth is not within the body of the Sun, nor so much as contiguous to it, but distant for some space from the same, and therefore assign to the Sun what other place you best like, as remote from the Earth as you please, and mark this in like manner.

SIMP. Here it is done: Let the place of the Solar body be O.

SALV. These two being constituted, I desire that we may think

think of accomodating the body of *Venus* in such a manner that its state and motion may agree with what sensible experiments do shew us ; and therefore recall to mind that which either by the past discourses , or your own observations you have learnt to befall that star , and afterwards assign unto it that state which you think agreeth with the same.

SIMP. Supposing those *Phænomena* expressed by you , and which I have likewise read in the little treatise of *Conclusions* , to



be true ; namely, that that star never recedes from the Sun beyond such a determinate space of 40 degrees or thereabouts , so as that it never cometh either to apposition with the Sun , or so much as to quadrature , or yet to the sextile aspect ; and more than that, supposing that it sheweth at one time almost 40 times greater than at another ; namely, very great, when being retrograde, it goeth to the vespertine conjunction of the Sun, and very small when with a

Venus very great towards the respective conjunction and very small towards the main time.

P p

motion

Venus necessarily proved to move about the Sun.

motion straight forwards, it goeth to the matutine conjunctions; and moreover it being true, that when it appeareth bigge it shews with a corniculate figure, and when it appeareth little, it seems perfectly round, these appearances, I say, being true, I do not see how one can choose but affirm the said star to revolve in a circle about the Sun, for that the said circle cannot in any wise be said to encompasse or to contain the Earth within it, nor to be inferiour to the Sun, that is between it and the Earth, nor yet superiour to the Sun. That circle cannot incompasse the Earth, because *Venus* would then sometimes come to opposition with the Sun; it cannot be inferiour, for then *Venus* in both its conjunctions with the Sun would seem horned; nor can it be superiour, for then it would always appear round, and never cornicular; and therefore for receipt of it I will draw the circle CH, about the Sun, without encompassing the Earth.

SALV. Having placed *Venus*, it is requisite that you think of *Mercury*, which, as you know, alwayes keeping about the Sun, doth recede lesse distance from it than *Venus*; therefore consider with your self, what place is most convenient to assign it.

The revolution of Mercury concluded to be about the Sun, within the Orb of Venus.

SIMP. It is not to be questioned, but that this Planet imitating *Venus*, the most commodious place for it will be, a lesser circle within this of *Venus*, in like manner about the Sun, being that of its greatest vicinity to the Sun, an argument, an evidence sufficiently proving the vigour of its illumination, above that of *Venus*, and of the other Planets, we may therefore upon these considerations draw its Circle, marking it with the Characters BG.

Mars necessarily includeth within his Orb the Earth, and also the Sun.

SALV. But *Mars*, Where shall we place it?

Mars at its opposition to the Sun shows to be sixty times bigger than towards the conjunction.

SIMP. *Mars*, Because it comes to an opposition with the Sun, its Circle must of necessity encompass the Earth; But I see that it must necessarily encompass the Sun also, for coming to conjunction with the Sun, if it did not move over it, but were below it, it would appear horned, as *Venus* and the Moon; but it shews alwayes round, and therefore it is necessary, that it no less includeth the Sun within its circle than the Earth. And because I remember that you did say, that when it is in opposition with the Sun, it seems 60 times bigger than when it is in the conjunction, me thinks that a Circle about the Centre of the Sun, and that raketh in the earth, will very well agree with these Phenomena, which I do note and mark DI, where *Mars* in the point D, is near to the earth, and opposite to the Sun; but when it is in the point I, it is at Conjunction with the Sun, but very far from the Earth. And because the same appearances are observed in *Jupiter* and *Saturn*, although with much lesser difference in *Jupiter* than in *Mars*, and with yet lesse in *Saturn* than in *Jupiter*; me thinks I

Jupiter and Saturn do likewise encompass the Earth, and the Sun.

un-

understand that we should very commodiously solve all the *Phænomena* of these two Planets, with two Circles, in like manner, drawn about the Sun, and this first for *Jupiter*, marking it E L, and another above that for *Saturn* marked F M.

SALV. You have behaved your self bravely hitherto. And because (as you see) the approach and recession of the three Superiour Planets is measured with double the distance between the Earth and Sun, this maketh greater difference in *Mars* than in *Jupiter*, the Circle D I, of *Mars*, being lesser than the Circle E L, of *Jupiter*, and likewise because this E L, is lesse than this Circle F M, of *Saturn*, the said difference is also yet lesser in *Saturn* than in *Jupiter*, and that punctually answereth the *Phænomena*. It remains now that you assign a place to the Moon.

SIMP. Following the same Method (which seems to me very conclusive) in regard we see that the Moon cometh to conjunction and opposition with the Sun, it is necessary to say, that its circle encompasseth the Earth, but yet doth it not follow, that it must environ the Sun, for then at that time towards its conjunction, it would not seem horned, but alwayes round and full of Light. Moreover it could never make, as it often doth, the Eclipse of the Sun, by interposing betwixt it and us; It is necessary therefore to assign it a circle about the Earth, which should be this N P, so that being constituted in P, it will appear from the Earth A, to be in conjunction with the Sun, and placed in N, it appeareth opposite to the Sun; and in that position it may fall under the Earths shadow, and be obscured.

SALV. Now, *Simplicius*, what shall we do with the fixed stars? Shall we suppose them scattered through the immense abiss of the Universe, at different distances, from any one determinate point; or else placed in a superficies spherically distended about a centre of its own, so that each of them may be equidistant from the said centre?

SIMP. I would rather take a middle way; and would assign them an Orb described about a determinate centre and comprized within two spherical superficies, to wit, one very high, and concave, and the other lower, and convex, betwixt which I would constitute the innumerable multitude of stars, but yet at divers altitudes, and this might be called the Sphere of the Universe, containing within it the Orbs of the planets already by us described.

SALV. But now we have all this while, *Simplicius*, disposed the mundane bodies exactly, according to the order of *Copernicus*, and we have done it with your hand; and moreover to each of them you have assigned peculiar motions of their own, except to the Sun, the Earth, and starry Sphere; and to *Mercury* with *Venus*, you have ascribed the circular motion about the Sun;

The approximation and recession of the three superiour Planets, importeth double the Suns distance.

The difference of the apparent magnitude lesse in Saturn, than in Jupiter, and in Jupiter than in Mars, and why.

The Moons Orb environeth the Earth, but not the Sun.

The probable situation of the fixed stars.

Which ought to be accounted the sphere of the Universe.

Rest, the annual motion and the diurnal ought to be distributed betwixt the Sun, Earth, and Firmament.

In a moveable sphere, it seemeth more reasonable that its centre be stable, than any other of its parts.

Granting to the Earth the annual, it must of necessity also have the diurnal motion assigned to it.

without encompassing the Earth; about the same Sun you make the three superiour Planets *Mars*, *Jupiter*, and *Saturn*, to move, comprehending the Earth within their circles. The Moon in the next place can move in no other manner than about the Earth, without taking in the Sun, and in all these motions you agree also with the same *Copernicus*. There remains now three things to be decided between the Sun, the Earth, and fixed stars, namely, Rest, which seemeth to belong to the Earth; the annual motion under the Zodiack, which appeareth to pertain to the Sun; and the diurnal motion, which seems to belong to the Starry Sphere, and to be by that imparted to all the rest of the Universe, the Earth excepted. And it being true that all the Orbs of the Planets, I mean of *Mercury*, *Venus*, *Mars*, *Jupiter*, and *Saturn*, do move about the Sun as their centre; rest seemeth with so much more reason to belong to the said Sun, than to the Earth, in as much as in a moveable Sphere, it is more reasonable that the centre stand still, than any other place remote from the said centre; to the Earth therefore, which is constituted in the midst of moveable parts of the Universe, I mean between *Venus* and *Mars*, one of which maketh its revolution in nine moneths, and the other in two years, may the motion of a year very commodiously be assigned, leaving rest to the Sun. And if that be so, it followeth of necessary consequence, that likewise the diurnal motion belongeth to the Earth; for, if the Sun standing still, the Earth should not revolve about its self, but have onely the annual motion about the Sun, our year would be no other than one day and one night; that is six moneths of day, and six moneths of night, as hath already been said. You may consider withal how commodiously the precipitate motion of 24 hours is taken away from the Universe, and the fixed stars that are so many Suns, are made in conformity to our Sun to enjoy a perpetual rest. You see moreover what facility one meets with in this rough draught to render the reason of so great appearances in the Celestial bodies.

SAGR. I very well perceive that facility, but as you from this simplicity collect great probabilities for the truth of that System, others haply could make thence contrary deductions; doubting, not without reason, why that same being the ancient Systeme of *Pythagoreans*, and so well accommodated to the *Phænomena*, hath in the succession of so many thousand years had so few followers, and hath been even by *Aristotle* himself refuted, and since that *Copernicus* himself hath had no better fortune.

SALV. If you had at any time been assaulted, as I have been, many and many a time, with the relation of such kind of frivolous reasons, as serve to make the vulgar contumacious, and difficult to be persuaded to hearken, (I will not say to consent) to this novelty,

ty, I believe that you wonder at the paucity of those who are followers of that opinion would be much diminished. But small regard in my judgement, ought to be had of such thick sculs, as think it a most convincing proof to confirm, and steadfastly tettle them in the belief of the earths immobility, to see that if this day they cannot Dine at *Constantinople*, nor Sup in *Jappan*, that then the Earth as being a most grave body cannot clamber above the Sun, and then slide headlong down again; Of such as these I say, whose number is infinite, we need not make any reckoning, nor need we to record their fooleries, or to strive to gain to our side as our partakers in subtil and sublime opinions, men in whose definition the kind onely is concerned, and the difference is wanting. Moreover, what ground do you think you could be able to gain, with all the demonstrations of the World upon brains so stupid, as are not able of themselves to know their down right follies? But my admiration, *Sagredus*, is very different from yours, you wonder that so few are followers of the *Pythagorean* Opinion; and I am amazed how there could be any yet left till now that do embrace and follow it: Nor can I sufficiently admire the eminencie of those mens wits that have received and held it to be true, and with the sprightlineffe of their judgements offered such violence to their own senses, as that they have been able to prefer that which their reason dictated to them, to that which sensible experiments represented most manifestly on the contrary. That the reasons against the Diurnal virtiginous revolution of the Earth by you already examined, do carry great probability with them, we have already seen; as also that the *Ptolomaicks*, and *Aristotelicks*, with all their Sectators did receive them for true, is indeed a very great argument of their efficacie; but those experiments which apertly contradict the annual motion, are of yet so much more manifestly repugnant, that (I say it again) I cannot find any bounds for my admiration, how that reason was able in *Aristarchus* and *Copernicus*, to commit such a rape upon their Sences, as in despight thereof, to make her self mistress of their credulity.

SAGR. Are we then to have still more of these strong oppositions against this annual motion?

SALV. We are, and they be so evident and sensible, that if a sence more sublime and excellent than those common and vulgar, did not take part with reason, I much fear, that I also should have been much more averse to the *Copernican* Systeem than I have been since the time that a clearer lamp than ordinary hath enlightned me.

SAGR. Now therefore *Salviatus*, let us come to joyn battail for every word that is spent on any thing else, I take to be cast away.

Discourses more than childish, serve to keep fools in the opinion of the Earths stability.

A declaration of the improbability of Copernicus his opinion.

Reasons and discourse in Aristarchus and Copernicus prevailed over manifest sence.

SALV.

Mars makes an
hot assault upon the
Copernican Sy-
steme.

The Phenome-
na of Venus appear
contrary to the Sy-
steme of Coperni-
cus.

Another diffi-
culty raised by Ve-
nus against Coperni-
cus.

Venus, according
to Copernicus, ei-
ther incid in it
self, or else of a
transparent sub-
stance.

Copernicus speak-
eth nothing of the
small variation of
bigness in Venus
and in Mars.

The moon much
disturbeth the or-
der of the other
Planets.

SALV. I am ready to serve you. You have already seen me draw the form of the *Copernican Systeme*; against the truth of which *Mars* himself, in the first place, makes an hot charge; who, in case it were true, that its distances from the earth should so much vary, as that from the least distance to the greatest, there were twice as much difference, as from the earth to the Sun; it would be necessary, that when it is nearest unto us, its *discus* would shew more than 60. times bigger than it seems, when it is farthest from us; nevertheless that diversity of apparent magnitude is not to be seen, nay in its opposition with the Sun, when its nearest to the Earth, it doth not shew so much as quadruple and quintuple in bigness, to what it is, when towards the conjunction it cometh to be occulted under the Sun's rays. Another and greater difficulty affirmeth, it were one while above, & another while below the same, receding and approaching to us so much as the Diameter of the circle described would be, at such time as it should be below the Sun, and nearest to us, its *discus* would shew little less than 40 times bigger than when it is above the Sun, near to its other conjunction; yet neverthelesse, the difference is almost imperceptible. Let us add another difficulty, that in case the body of *Venus* be of it self dark, and onely shineth as the Moon, by the illumination of the Sun; which seemeth most reasonable; it would shew forked or horned at such time as it is under the Sun, as the Moon doth when she is in like manner near the Sun; an accident that is not to be discovered in her. Whereupon *Copernicus* affirmeth, that either she is light of her self, or else that her substance is of such a nature, that it can imbue the Solar light, and transmit the same through all its whole depth, so as to be able to appear to us alwayes shining; and in this manner *Copernicus* excuseth the not changing figure in *Venus*: but of her small variation of Magnitude, he maketh no mention at all; and much less of *Mars* than was needful; I believe as being unable so well as he desired to salve a *Phænomenon* so contrary to his Hypothesis, and yet being convinced by so many other occurrences and reasons he maintained, and held the same Hypothesis to be true. Besides these things, to make the Planets, together with the Earth, to move above the Sun as the Centre of their conversions, and the Moon onely to break that order, and to have a motion by it self about the earth; and to make both her, the Earth, and the whole Elementary Sphere, to move all together about the Sun in a year, this seemeth to pervert the order of this Systeme, which rendreth it unlikely and false. These are those difficulties that make me wonder how *Aristarchus* and *Copernicus*, who must needs have observed them, not having been able for all that to salve them, have yet notwithstanding by other admirable occurrences been induced

to confide so much in that which reason dictated to them, as that they have confidently affirmed that the structure of the Universe could have no other figure than that which they designed to themselves. There are also several other very serious and curious doubts, not so easie to be resolved by the middle sort of wits, but yet penetrated and declared by *Copernicus*, which we shall defer till by and by, after we have answered to other objections that seem to make against this opinion. Now coming to the declarations and answers to those three before named grand Objections, I say, that the two first not onely contradict not the *Copernican* Systeme, but greatly and absolutely favour it; For both *Mars* and *Venus* seems unequal to themselves, according to the proportions assigned; and *Venus* under the Sun seemeth horned, and goeth changing figures in it self exactly like the Moon.

SAGR. But how came this to be concealed from *Copernicus*, and revealed to you?

SALV. These things cannot be comprehended, save onely by the sense of seeing, the which by nature was not granted to man so perfect, as that it was able to attain to the discovery of such differences; nay even the very instrument of sight is an impediment to it self: But since that it hath pleased God in our age to vouchsafe to humane ingenuity, so admirable an invention of perfecting our sight, by multiplying it four, six, ten, twenty, thirty, and forty times, infinite objects, that either by reason of their distance, or for their extream smallnesse were invisible unto us, have by help of the Telescope been rendered visible.

SAGR. But *Venus* and *Mars* are none of the objects invisible for their distance or smallnesse, yea, we do discern them with our bare natural sight; why then do we not distinguish the differences of their magnitudes and figures?

SALV. In this, the impediment of our very eye it self hath a great share, as but even now I hinted, by which the resplendent and remote objects are not represented to us simple and pure; but gives them us fringed with strange and adventitious rayes, so long and dense, that their naked body sheweth to us agrandized ten, twenty, an hundred, yea a thousand times more than it would appear, if the capillitious rayes were taken away.

SAGR. Now I remember that I have read something on this subject, I know not whether in the Solar Letters, or in the *Saggiatore* of our common Friend, but it would be very good, as well for recalling it into my memory, as for the information of *Simplicius*, who it may be never saw those writings, that you would declare unto us more distinctly how this businesse stands, the knowledge whereof I think to be very necessary for the assisting of us to understand that of which we now speak.

Answers to the three first objections against the Copernican Systeme.

The reason whence it happens that Venus and Mars do not appear to vary magnitude so much as is requisite.

SIMP.

*The operations of
the Telescope ac-
counted fallacies by
the Peripateticks.*

*Shining objects
seem environed
with adventitious
rayes.*

*The reason why
luminous bodies ap-
pear enlarged
much the more, by
how much they are
lesser.*

*Superficial fi-
gures encreasing
proportion double to
their lines.*

SIMP. I must confesse that all that which *Salvians* hath spoken is new unto me, for truth is, I never have had the curiosity to read those Books, nor have I hitherto given any great credit to the Telescope newly introduced; rather treading in the steps of other *Peripatetick* Philosophers my companions, I have thought those things to be fallacies and delusions of the Chrystals, which others have so much admired for stupendious operations: and therefore if I have hitherto been in an errour, I shall be glad to be freed from it, and allured by these novelties already heard from you, I shall the more attentively hearken to the rest.

SALV. The confidence that these men have in their own apprehensiveness, is no less unreasonable than the small esteem they have of the judgment of others: yet its much that they should esteem themselves able to judge better of such an instrument, without ever having made trial of it, than those who have made, and daily do make a thousand experiments of the same: But I pray you, let us leave this kind of pertinacious men, whom we cannot so much as tax without doing them too great honour. And returning to our purpose, I say, that resplendent objects, whether it is that their light doth refract on the humidity that is upon the pupils, or that it doth reflect on the edges of the eye-browes, diffusing its reflex rayes upon the said pupils, or whether it is for some other reason, they do appear to our eye, as if they were environ'd with new rayes, and therefore much bigger than their bodies would represent themselves to us, were they divested of those irradiations. And this aggrandizement is made with a greater and greater proportion, by how much those lucid objects are lesser and lesser; in the same manner for all the world, as if we should suppose that the augmentation of shining locks were *v.g.* four inches, which addition being made about a circle that hath four inches diameter would increale its appearance to nine times its former bignesse: but——

SIMP. I believe you would have said three times; for adding four inches to this side, and four inches to that side of the diameter of a circle, which is likewise four inches, its quantity is thereby tripled, and not made nine times bigger.

SALV. A little more *Geometry* would do well, *Simplicius*. True it is, that the diameter is tripled, but the superficies, which is that of which we speak, increaseth nine times: for you must know, *Simplicius*, that the superficies of circles are to one another, as the squares of their diameters; and a circle that hath four inches diameter is to another that hath twelve, as the square of four to the square of twelve; that is, as 16. is to 144. and therefore it shall be increased nine times, and not three; this, by way of advertisement to *Simplicius*. And proceeding forwards, if we should add the

the said irradiation of four inches to a circle that hath but two inches of diameter onely, the diameter of the irradiation or Garland would be ten inches, and the superficial content of the circle would be to the *area* of the naked body, as 100. to 4. for those are the squares of 10. and of 2. the agrandizement would therefore be 25. times so much; and lastly, the four inches of hair or fringe, added to a small circle of an inch in diameter, the same would be increased 81. times; and so continually the augmentations are made with a proportion greater and greater, according as the real objects that increase, are lesser and lesser.

S A G R O. The doubt which puzzled *Simplificus* never troubled me, but certain other things indeed there are, of which I desire a more distinct understanding; and in particular, I would know upon what ground you affirm that the said agrandizement is alwayes equal in all visible objects.

S A L V. I have already declared the same in part, when I said, that onely lucid objects so increased, and not the obscure; now I adde what remaines, that of the resplendent objects those that are of a more bright light, make the reflection greater and more resplendent upon our pupil; whereupon they seem to augment much more than the lesse lucid: and that I may no more enlarge my self upon this particular, come we to that which the true Mistress of *Astronomy*, Experience, teacheth us. Let us this evening, when the air is very obscure, observe the star of *Jupiter*; we shall see it very glittering, and very great; let us afterwards look through a tube, or else through a small trunk, which clutching the hand close, and accosting it to the eye, we lean between the palm of the hands and the fingers, or else by an hole made with a small needle in a paper; and we shall see the said star divested of its beams, but so small, that we shall judge it lesse, even than a sixtieth part of its great glittering light seen with the eye at liberty: we may afterwards behold the *Dog-stars* beautiful and bigger than any of the other fixed stars, which seemeth to the bare eye no great matter lesse than *Jupiter*; but taking from it, as before, the irradiation, its *Discus* will shew so little, that it will not be thought the twentieth part of that of *Jupiter*, nay, he that hath not very good eyes, will very hardly discern it; from whence it may be rationally inferred, that the said star, as having a much more lively light than *Jupiter*, maketh its irradiation greater than *Jupiter* doth his. In the next place, as to the irradiation of the Sun and Moon, it is as nothing, by means of their magnitude, which possesseth of it self alone so great a space in our eye, that it leaveth no place for the adventitious rayes; so that their faces seem close clipt, and terminate. We may assure our selves of the same truth by another experiment which I have often made triall of;

Q. 9

Objects the more vigorous they are in light, the more they do seem to increase.

An easie experiment that sheweth the increase in the stars, by means of the adventitious rays.

Jupiter augments lesse than the Dog-star.

The Sun and Moon increase little.

we

It is seen by manifest experience, that the more splendid bodies do much more irradiate than the lesse lucid.

The Telescope is the best means to take away the irradiations of the Stars.

Another second reason of the small apparent increase of Venus.

Copernicus perswaded by reasons contrary to sensible experiments.

we may assure our selves, I say, that bodies shining with most lively light do irradiate, or beam forth rayes more by far than those that are of a more languishing light. I have many times seen *Jupiter* and *Venus* together twenty or thirty degrees distant from the Sun, and the air being very dark, *Venus* appeared eight or ten times bigger than *Jupiter*, being both beheld by the eye at liberty; but being beheld afterwards with the Telescope, the *Discus* of *Jupiter* discovered it self to be four or more times greater than that of *Venus*, but the vivacity of the splendour of *Venus* was incomparably bigger than the languishing light of *Jupiter*; which was only becaule of *Jupiter*s being far from the Sun, and from us; and *Venus* neer to us, and to the Sun. These things premised, it will not be difficult to comprehend, how Mars, when it is in opposition to the Sun, and therefore neerer to the Earth by seven times and more, than it is towards the conjunction, cometh to appear scarce fout or five times bigger in that state than in this, when as it should appear more than fifty times so much; of which the only irradiation is the cause; for if we divest it of the adventitious rayes, we shall find it exactly augmented with the due proportion: but to take away the capillitious border, the Telescope is the best and only means, which enlarging its *Discus* nine hundred or a thousand times, makes it to be seen naked and terminate, as that of the Moon, and different from it self in the two positions, according to its due proportions to an hair. Again, as to *Venus*, that in its vespertine conjunction, when it is below the Sun, ought to shew almost forty times bigger than in the other matutine conjunction, and yet doth not appear so much as doubled; it happeneth, besides the effect of the irradiation, that it is horned; and its crescents, besides that they are sharp, they do receive the Suns light obliquely, and therefore emit but a faint splendour; so that as being little and weak, its irradiation becometh the lesse ample and vivacious, than when it appeareth to us with its Hemisphere all shining: but now the Telescope manifestly shews its hornes to have been as terminate and distinct as those of the Moon, and appear, as it were, with a great circle, and in a proportion those well neer forty times greater than its same *Discus*, at such time as it is superiour to the Sun in its ultimate matutine apparition.

SAGR. Oh, *Nicholas Copernicus*, how great would have been thy joy to have seen this part of thy Systeme, confirmed with so manifest experiments!

SALV. Tis true. But how much lesse the fame of his sublime wit amongst the intelligent? when as it is seen, as I also said before, that he did constantly continue to affirm (being perswaded thereto by reason) that which sensible experiments seemed to contradict; for I cannot cease to wonder that he should constantly persist in saying, that *Venus* revolveth about the Sun, and is more than six

times farther from us at one time, than at another; and also seemeth to be alwayes of an equal bigness, although it ought to shew forty times bigger when nearest to us, than when farthest off.

SAGR. But in *Jupiter*, *Saturn* and *Mercury*, I believe that the differences of their apparent magnitudes, should seem punctually to answer to their different distances.

SALV. In the two Superiour ones, I have made precise observations yearly for this twenty two years last past: In *Mercury* there can be no observation of moment made, by reason it suffers not it self to be seen; save onely in its greatest digressions from the Sun, in which its distances from the earth are insensibly unequal, and those differences consequently not to be observed; as also its mutations of figures which must absolutely happen in it, as in *Venus*. And if we do see it, it must of necessity appear in form of a Semicircle, as *Venus* likewise doth in her greatest digressions; but its *discus* is so very small, and its splendor so very great, by reason of its vicinity to the Sun, that the virtue of the Telescope doth not suffice to clip its tresses or adventitious rayes, so as to make them appear shaved round about. It remains, that we remove that which seemed a great inconvenience in the motion of the Earth; namely that all the Planets moving about the Sun, it alone, not solitary as the rest, but in company with the Moon, and the whole Elementary Sphear, should move round about the Sun in a year; and that the said Moon withal should move every moneth about the earth. Here it is necessary once again to exclaim and extol the admirable perspicacity of *Copernicus*, and withal to condole his misfortune, in that he is not now alive in our dayes; when for removing of the seeming absurdity of the Earth and Moons motion in consort we see *Jupiter*, as if it were another Earth, not in consort with the Moon, but accompanied by four Moons to revolve about the Sun in 12. years together, with what ever things the Orbs of the four *Medicean* Stars can contain within them.

SALV. Why do you call the four jovial Planets, Moons?

SAGR. Such they would seem to be to one that standing in *Jupiter* should behold them; for they are of themselves dark, and receive their light from the Sun, which is manifest from their being eclipsed, when they enter into the cone of *Jupiter's* shadow: and because onely those their Hemispheres, that look towards the Sun are illuminated, to us that are without their Orbs, and nearer to the Sun, they seem alwayes *lucid*, but to one that should be in *Jupiter*, they would shew all illuminated, at such time as they were in the upper parts of their circles; but in the parts inferior, that is between *Jupiter* and the Sun, they would from *Jupiter* be observed to be horned; and in a word they would, to

Q. 2

Mercury admits such not of clear observations.

The difficulties removed that arise from the Earths moving about the Sun, not solitarily, but in consort with the Moon.

The Medicean Stars are as it were four Moons about Jupiter.

the observators standing in *Jupiter*, make the self same changes of Figure, that to us upon the Earth, the Moon doth make. You see now how these three things, which at first seemed dissonant, do admirably accord with the *Copernican* Systeme. Here also by the way may *Simplicius* see, with what probability one may conclude, that the Sun and not the Earth, is in the Centre of the *Planetary* conversions. And since the Earth is now placed amongst mundane Bodies, that undoubtedly move about the Sun, to wit, above *Mercury* and *Venus*, and below *Saturnus*, *Jupiter*, and *Mars*; shall it not be in like manner probable, and perhaps necessary to grant, that it also moveth round?

STIMP. These accidents are so notable and conspicuous, that it is not possible, but that *Ptolomy* and others his Sectators, should have had knowledge of them, and having so, it is likewise necessary, that they have found a way to render reasons of such, and so sensible appearances that were sufficient, and also congruous and probable, seeing that they have for so long a time been received by such numbers of learned men.

The Principal scope of Astronomers, is to give a reason of appearances.

Copernicus restored Astronomy upon the suppositions of Ptolomy:

What moved Copernicus to establish his Systeme.

SALV. You argue very well; but you know that the principal scope of *Astronomers*, is to render only reason for the appearances in the *Cælestial* Bodies, and to them, and to the motions of the Stars, to accomodate such structures and compositions of Circles, that the motions following those calculations, answer to the said appearances, little scrupling to admit of some exorbitances, that indeed upon other accounts they would much stick at. And *Copernicus* himself writes, that he had in his first studies restored the Science of *Astronomy* upon the very suppositions of *Ptolomy*, and in such manner corrected the motions of the Planets, that the computations did very exactly agree with the *Phænomena*, and the *Phænomena* with the supputations, in case that he took the Planets severally one by one. But he addeth, that in going about to put together all the structures of the particular Fabricks, there resulted thence a Monster and *Chimera*, composed of members most disproportionate to one another, and altogether incompatible; So that although it satisfied an *Astronomer* merely *Arithmetical*, yet did it not afford satisfaction or content to the *Astronomer* *Phylosophical*. And because he very well understood, that if one might salve the *Cælestial* appearances with false assumptions in nature, it might with much more ease be done by true suppositions, he set himself diligently to search whether any amongst the antient men of fame, had ascribed to the World any other structure, than that commonly received by *Ptolomy*; and finding that some *Pythagoreans* had in particular assigned the Diurnal conversion to the Earth, and others the annual motion also, he began to compare the appearances, and particularities

ties of the Planets motions, with these two new suppositions, all which things jump exactly with his purpose; and seeing the whole correspond, with admirable facility to its parts, he embraced this new System; and it took up his rest.

SIMP. But what great exorbitancies are there in the *Ptolomaick* System, for which there are not greater to be found in this of *Copernicus*?

SALV. In the *Ptolomaick Hypothesis* there are diseases, and in the *Copernican* their cures. And first will not all the Sects of *Philosophers*, account it a great inconvenience, that a body naturally moveable in circumscription, should move irregularly upon its own Centre, and regularly upon another point? And yet there are such deformed motions as these in the *Ptolomaean Hypothesis*, but in the *Copernican* all move evenly about their own Centres. In the *Ptolomaick*, it is necessary to assign to the *Cælestial* bodies, contrary motions, and to make them all to move, from East to West, and at the same time, from West to East; But in the *Copernican*, all the *Cælestial* revolutions are towards one onely way, from West to East. But what shall we say of the apparent motion of the Planets, so irregular, that they not onely go one while swift, and another while slow, but sometimes wholly cease to move; and then after a long time return back again? To salve which appearances *Ptolomie* introduceth very great *Epicicles*, accommodating them one by one to each Planet, with some rules of incongruous motions, which are all with one single motion of the Earth taken away. And would not you, *Simplicius*, call it a great absurditie, if in the *Ptolomaick Hypothesis*, in which the particular Planets, have their peculiar Orbs assigned them one above another, one must be frequently forced to say, that *Mars*, constituted above the Sphere of the Sun, doth so descend, that breaking the Solar Orb, it goeth under it, and approacheth nearer to the Earth, than to the Body of the Sun, and by and by immeasurably ascendeth above the same? And yet this, and other exorbitancies are remedied by the sole and single annual motion of the Earth.

SAGR. I would gladly be better informed how these Stations, and retrograde and direct motions, which did ever seem to me great improbabilities, do accord in this *Copernican* Systeme.

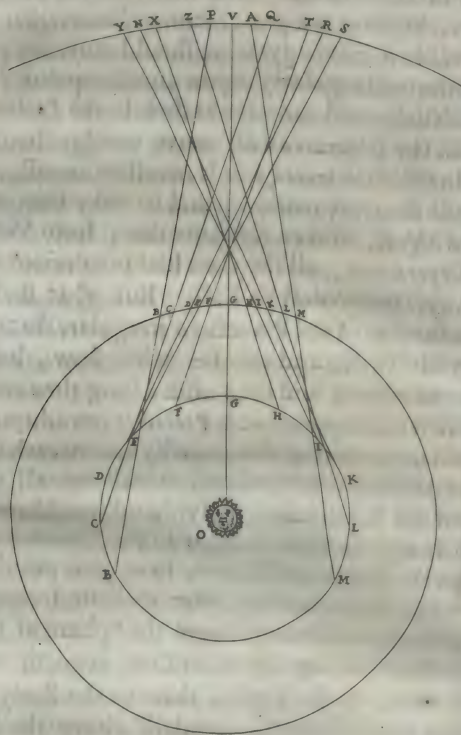
SALV. You shall see them so to accord, *Sagredus*, that this onely conjecture ought to be sufficient to make one that is not more than pertinacious or stupid, yield, assent to all the rest of this Doctrine. I tell you therefore, that nothing being altered in the motion of *Saturn*, which is 30 years; in that of *Jupiter*, which is 12; in that of *Mars*, which is 2; in that of *Venus*, which is 9. moneths; in that of *Mercury*, which is 80. dayes,

Inconveniencies that are in the Systeme of Ptolomy.

Is a great Argument in favour of Copernicus, that he obviates the Stations & retrogradations of the motions of the Planets.

The sole annual motion of the Earth causeth great inequality of motions in the five Planets.

dayes, or thereabouts, the sole annual motion of the Earth between *Mars* and *Venus*, causeth the apparent inequalities in all the five stars before named. And for a facile and full understanding of the whole, I will describe this figure of it. Therefore suppose the Sun to be placed in the centre O, about which we will draw the Orb described by the Earth, with the annual motion B G M, and let the circle described, *v. gr.* by *Jupiter* about the Sun in 12. years, be this B G M, and in the



A demonstration of the inequalities of the three superior Planets dependent on the annual motion of the Earth.

starry sphere let us imagine the Zodiack Y V S. Again, in the annual Orb of the Earth let us take certain equal arches, B C, C D, E F, F G, G H, H I, I K, K L, L M, and in the Sphere of *Jupiter* let us make certain other arches, passed in the same times in which the Earth passeth hers, which let be E C, C D, D E, E F, F G, G H, H I, I K, K L, L M, which shall each be proportionally lesse than these marked in the Earths Orb, like as the motion of *Jupiter* under the Zodiack is slower than the annual. Supposing now, that when the Earth is in B, *Jupiter* is in B: it shall appear to us in the Zodiack to be in P, describing the

the right line B B P. Next suppose the Earth to be moved from B to C, and *Jupiter* from B to c, in the same time; *Jupiter* shall appear to have passed in the Zodiack to Q, and to have moved straight forwards, according to the order of the signes P Q. In the next place, the Earth passing to D, and *Jupiter* to d, it shall be seen in the Zodiack in R, and from B, *Jupiter* being come to e, will appear in the Zodiack in S, having all this while moved right forwards. But the Earth afterwards beginning to interpose more directly between *Jupiter* and the Sun, she being come to F, and *Jupiter* to f, he will appear in T, to have already begun to return apparently back again under the Zodiack, and in that time that the Earth shall have passed the arch EF, *Jupiter* shall have entertained himself between the points ST, and shall have appeared to us almost motionlesse and stationary. The Earth being afterwards come to G, and *Jupiter* to g, in opposition to the Sun, it shall be visible in the Zodiack at V, and much returned backwards by all the arch of the Zodiack TV; howbeit that all the way pursuing its even course it hath really gone forwards not onely in its own circle, but in the Zodiack also in respect to the centre of the said Zodiack, and to the Sun placed in the same. The Earth and *Jupiter* again continuing their motions, when the Earth is come to H, and *Jupiter* to h, it shall seem very much gone backward in the Zodiack by all the arch VX. The Earth being come to P, and *Jupiter* to p, it shall be apparently moved in the Zodiack by the little space XY, and there it will seem stationary. When afterwards the Earth shall be come to K, and *Jupiter* to k, in the Zodiack he shall have passed the arch YN in a direct motion; and the Earth pursuing its course to L, shall see *Jupiter* in L, in the point Z. And lastly *Jupiter* in m shall be seen from the Earth M, to have passed to A, with a motion still right forwards; and its whole apparent retrogradation in the Zodiack shall answer to the arch SY, made by *Jupiter*, whilst that he in his own circle passeth the arch EI, and the Earth in hers the arch EL. And this which hath been said, is intended of *Saturn* and of *Mars* also; and in *Saturn* those retrogradations are somewhat more frequent than in *Jupiter*, by reason that its motion is a little slower than that of *Jupiter*; so that the Earth overtaketh it in a shorter space of time; in *Mars* again they are more rare, for that its motion is more swift than that of *Jupiter*. Whereupon the Earth consumeth more time in recovering it. Next as to *Venus* and *Mercury*, whose Circles are comprehended by that of the Earth, their stations and regressions appear to be occasioned, not by their motions that really are such, but by the anual motion of the said Earth, as *Copernicus* excellently demonstrateth,

Retrogradations more frequent in Saturn, lesse in Jupiter, and yet lesse in Mars, and why.

The Retrogradation of Venus and Mercury demonstrated by Apollonius and Copernicus.

to-

together with *Appollonius Pergæus* in *lib. 5.* of his *Revolutions*, *Chap. 35.*

The annual motion of the Earth most apt to render a reason of the ex-orbitances of the five Planets.

The Sun it self testifieth the annual motion to belong to the Earth.

You see, Gentlemen, with what facility and simplicity the annual motion, were it appertaining to the Earth, is accommodated to render a reason of the apparent exorbitances, that are observed in the motions of the five Planets, *Saturn, Jupiter, Mars, Venus* and *Mercury*, taking them all away, and reducing them to equal and regular motions. And of this admirable effect, *Nicholas Copernicus*, hath been the first that hath made the reason plain unto us. But of another effect, no lesse admirable than this, and that with a knot, perhaps more difficult to unknot, binderth the wit of man, to admit this annual conversion, and to leave it to our Terrestrial Globe; a new and unthought of conjecture ariseth from the Sun it self, which sheweth that it is unwilling to be singular in shifting, of this attestation of so eminent a conclusion, rather as a testimony beyond all exception, it hath desired to be heard apart. Harken then to this great and new wonder.

The Lyncean Academick the first discoverer of the Solar spots, and all the other celestial novelties.

The history of the proceedings of the Academick for a long time about the observation of the Solar spots.

* Duumviro.

The first discoverer and observer of the Solar spots, as also of all the other Cœlestial novelties, was our *Academick Lyncean*; and he discovered them anno 1610. being at that time Reader of the *Mathematicks*, in the Colledge of *Padua*, and there, and in *Venice*, he discoursed thereof with several persons, of which some are yet living: And the year following, he shewed them in *Rome* to many great personages, as he relates in the first of his Letters to *Marcus Velserns*, * Sheriffe of *Augusta*. He was the first that against the opinions of the too timorous and too jealous assertors of the Heavens inalterability, affirmed those spots to be matters, that in short times were produced and dissolved: for as to place, they were contiguous to the body of the Sun, and revolved about the same; or else being carried about by the said Solar body, which revolveth in it selfe about its own Centre, in the space almost of a moneth, do finish their course in that time; which motion he judged at first to have been made by the Sun about an Axis erected upon the plane of the *Ecliptick*; in regard that the arches described by the said spots upon the *Discus* of the Sun appear unto our eye right lines, and parallels to the plane of the *Ecliptick*: which therefore come to be altered, in part, with some accidental, wandring, and irregular motions, to which they are subject, and whereby tumultuarily, and without any order they successively change situations amongst themselves, one while crouding close together, another while dissevering, and some dividing themselves into many and very much changing figures, which, for the most part, are very unusual. And albeit those so inconstant mutations did somewhat alter the primary periodick

ridick course of the said spots, yet did they not alter the opinion of our friend, so as to make him believe, that they were any essential and fixed cause of those deviations, but he continued to hold, that all the apparent alterations derived themselves from those accidental mutations: in like manner, just as it would happen to one that should from far distant Regions observe the motion of our Clouds; which would be discovered to move with a most swift, great, and constant motion, carried round by the diurnal *Vertigo* of the Earth (if haply that motion belong to the same): in twenty four hours, by circles parallel to the Equinoctial, but yet altered, in part, by the accidental motions caused by the winds, which drive them, at all adventures, towards different quarters of the World. While this was in agitation, it came to pass that *Velsenus* sent him two Letters, written by a certain person, under the feigned name of * *Apelles*, upon the subject of these Spots, requesting him, with importunity, to declare his thoughts freely upon those Letters, and withall to let him know what his opinion was touching the essence of those spots; which his request he satisfied in 3 Letters, shewing first of all how vain the conjectures of *Apelles* were; & discovering, secondly, his own opinions; withal foretelling to him, that *Apelles* would undoubtedly be better advised in time, and turn to his opinion, as it afterwards came to pass. And because that our Academician (as it was also the judgment of many others that were intelligent in Nature's secrets) thought he had in those three Letters investigated and demonstrated, if not all that could be desired, or required by humane curiosity, at least all that could be attained by humane reason in such a matter, he, for some time (being busied in other studies) intermitted his continual observations, and onely in complacency to some friend, joyned with him, in making now and then an abrupt observation: till that he, and after some years, we, being then at my * Country-seat, met with one of the solitary Solar spots very big, and thick, invited withal by a clear and constant serenity of the Heavens, he, at my request, made observations of the whole progresse of the said spot, carefully marking upon a sheet of paper the places that it was in every day at the time of the Sun's coming into the Meridian; and we having found that its course was not in a right line, but somewhat incurvated, we came to resolve, at last, to make other observations from time to time; to which undertaking we were strongly induced by a conceit, that accidentally came into the minde of my Guest, which he imparted to me in these or the like words.

In my opinion, *Philip*, there is a way opened to a business of very great consequence. For if the Axis about which the Sun turneth be not erect perpendicularly to the plane of the Ecliptick,

R r

* This Authors true name is *Christopher Scheiner* a Jesuit, and his Book here meant is intitled, *Apelles post tabulam*.

* *La mia villa delle Selue*.

A conceipt that came suddenly into the minde of the Academick Lynceus concerning the great consequence that followed upon the motion of the Solar spots.

Extravagant mutations to be observed in the motions of the spots, foreseen by the Academick, in case the Earth had the annual motion.

tick, but is inclined upon the same, as its crooked course, but even now observed, makes me believe, we shall be able to make such conjectures of the states of the Sun and Earth, as neither so solid or so rational have been hitherto deduced from any other accident whatsoever. I being awakened at so great a promise, importun'd him to make a free discovery of his conceit unto me. And he continued his discourse to this purpose. If the Earths motion were along the Ecliptique about the Sun; and the Sun were constituted in the centre of the said Ecliptick, and therein revolved in its self, not about the Axis of the said Ecliptique (which would be the Axis of the Earths annual motion) but upon one inclined, it must needs follow, that strange changes will represent themselves to us in the apparent motions of the Solar spots, although the said Axis of the Sun should be supposed to persist perpetually and immutably in the same inclination, and in one and the same direction towards the self-same point of the Universe. Therefore the Terrestrial Globe in the annual motion moving round it, it will first follow, that to us, carried about by the same, the courses of the spots shall sometimes seem to be made in right lines, but this only twice a year, and at all other times shall appear to be made by arches insensibly incurvated. Secondly, the curvity of those arches for one half of the year, will shew inclined the contrary way to what they will appear in the other half; that is, for six moneths the convexity of the arches shall be towards the upper part of the Solar *Discus*, and for the other six moneths towards the inferiour. Thirdly, the spots beginning to appear, and (if I may so speak) to rise to our eye from the left side of the Solar *Discus*, and going to hide themselves and to set in the right side, the Oriental termes, that is, of their first appearings for six moneths, shall be lower than the opposite termes of their occultations; and for other six moneths it shall happen contrarily, to wit, that the said spots rising from more elevated points, and from them descending, they shall, in their courses, go and hide themselves in lower points; and onely for two dayes in all the year shall those termes of risings and settings be equilibrated: after which freely beginning by small degrees the inclination of the courses of the spots, and day by day growing bigger, in three moneths, it shall arrive at its greatest obliquity, and from thence beginning to diminish, in such another time it shall reduce it self to the other *Equilibrium*. It shall happen, for a fourth wonder, that the course of the greatest obliquity shall be the same with the course made by the right line, and in the day of the Libration the arch of the course shall seem more than ever incurvated. Again, in the other times, according as the pendency shall successively diminish, and make its approach

proach towards the *Æquilibrium*, the incurvation of the arches of the courses on the contrary shall, by degrees, increase.

SAGR. I confesse, *Salvatus*, that to interrupt you in your Discourse is ill manners, but I esteem it no lesse rudeness to permit you to run on any farther in words; whilst they are, as the saying is, cast into the air: for, to speak freely, I know not how to form any distinct conceit of so much as one of these conclusions, that you have pronounced; but because, as I thus generally and confusedly apprehend them, they hold forth things of admirable consequence, I would gladly, some way or other, be made to understand the same.

SALV. The same that befalls you, befell me also, whilst my Guest transported me with bare words; who afterwards assisted my capacity, by describing the business upon a material Instrument, which was no other than a simple Sphere, making use of some of its circles, but to a different purpose from that, to which they are commonly applied. Now I will supply the defect of the Sphere, by drawing the same upon a piece of paper, as need shall require. And to represent the first accident by me propounded, which was, that the courses or journeys of the spots, twice a year, and no more, might be seen to be made in right lines, let us suppose this point O [in Fig. 4.] to be the centre of the grand Orb, or, if you will, of the *Ecliptick*, and likewise also of the Globe of the Sun it self; of which, by reason of the great distance that is between it and the Earth, we that live upon the Earth, may suppose that we see the one half: we will therefore describe this circle A B C D about the said centre O, which representeth unto us the extream term that divideth and separates the Hemisphere of the Sun that is apparent to us, from the other that is occult. And because that our eye, no lesse than the centre of the Earth, is understood to be in the plane of the *Ecliptick*, in which is likewise the centre of the Sun, therefore, if we should fancy to our selves the body of the Sun to be cut thorow by the said plane, the section will appear to our eye a right line, which let be B O D; and upon that a perpendicular being let fall A O C, it shall be the Axis of the said *Ecliptick*, and of the annual motion of the Terrestrial Globe. Let us next suppose the Solar body (without changing centre) to revolve in it self, not about the Axis A O C (which is the erect Axis upon the plane of the *Ecliptick*) but about one somewhat inclined, which let be this E O I, the which fixed and unchangeable Axis maintaineth it self perpetually in the same inclination and direction towards the same points of the Firmament, and of the Universe. And because, in the revolutions of the Solar Globe; each point of its superficies (the Poles excepted) describeth the circumference of a

The first Accident to be observed in the motion of the Solar spots; and consequently all the rest explained.

R r 2

circle

circle, either bigger or lesser, according as it is more or lesse remote from the said Poles, let us take the point F, equally distant from them, and draw the diameter F O G, which shall be perpendicular to the Axis E I, and shall be the diameter of the grand circle described about the Poles E I. Supposing not that the Earth, and we with her be in such a place of the Ecliptick, that the Hemisphere of the Sun to us apparent is determin'd or bounded by the circle A B C D, which passing (as it alwayes doth) by the Poles A C, passeth also by E I. It is manifest, that the grand circle, whose diameter is F G, shall be erect to the circle A B C D, to which the ray that from our eye falleth upon the centre O, is perpendicular; so that the said ray falleth upon the plane of the circle, whose diameter is F G, and therefore its circumference will appear to us a right line, and the self same with F G, whereupon if there should be in the point F, a spot, it coming afterwards to be carried about by the Solar conversion, would, upon the surface of the Sun, trace out the circumference of that circle, which seems to us a right line. Its course or passage will therefore seem straight. And straight also will the motion of the other spots appear, which in the said revolution shall describe lesser circles, as being all parallel to the greater, and to our eye placed at an immense distance from them. Now, if you do but consider, how that after the Earth shall in six moneths have run thorow half the grand Orb, and shall be situate opposite to that Hemisphere of the Sun, which is now occult unto us, so as that the boundary of the part that then shall be seen, may be the self same A B C D, which also shall passe by the Poles E I; you shall understand that the same will evene in the courses of the spots, as before, to wit, that all will appear to be made by right lines. But because that that accident takes not place, save onely when the terminator or boundary passeth by the Poles E I, and the said terminator from moment to moment, by meanes of the Earths annual motion, continually altereth, therefore its passage by the fixed Poles E I, shall be momentary, and consequently momentary shall be the time, in which the motions of those spots shall appear straight. From what hath been hitherto spoken one may comprehend also how that the apparition and beginning of the motion of the spots from the part F, proceeding towards G, their passages or courses are from the left hand, ascending towards the right; but the Earth being placed in the part diametrically opposite the appearance of the spots about G, shall still be to the left hand of the beholder, but the passage shall be descending towards the right hand F. Let us now describe the Earth re be situate one fourth part farther distant from its present state, and let us draw, as in the other figure, the terminator A B C D,

[as

[as in Fig. 5.] and the Axis, as before A C, by which the plane of our Meridian would passe, in which plane should also be the Axis of the Suns revolution, with its Poles, one towards us, that is, in the apparent Hemisphere, which Pole we will represent by the point E, and the other shall fall in the occult Hemisphere, and I mark it I. Inclining therefore the Axis E I, with the superiour part E, towards us, the great circle described by the Suns conversion, shall be this B F D G, whose half by us seen, namely B F D, shall no longer seem unto us a right line, by reason the Poles E I are not in the circumference A B C D, but shall appear incurvated, and with its convexity towards the inferiour part C. And it is manifest, that the same will appear in all the lesser circles parallel to the same B F D. It is to be understood also, that when the Earth shall be diametrically opposite to this state, so that it seeth the other Hemisphere of the Sun, which now is hid, it shall of the said great circle behold the part D G B incurved, with its convexity towards the superiour part A; and the courses of the spots in these constitutions shall be first, by the arch B F D, and afterwards by the other D G B, and the first apparitions and ultimate occultations made about the points B and D, shall be equilibrated, and not those that are more or lesse elevated than these. But if we constitute the Earth in such a place of the Ecliptick, that neither the boundary A B C D, nor the Meridian A C, passeth by the Poles of the Axis E I, as I will shew you anon, drawing this other Figure [*viz.* Fig. 6.] wherein the apparent or visible Pole E falleth between the arch of the terminator A B, and the section of the Meridian A C; the diameter of the great circle shall be F O G, and the apparent semicircle F N G, and the occult semicircle G S F, the one incurvated with its convexity N towards the inferiour part, and the other also bending with its convexity S towards the upper part of the Sun. The ingressions and exitions of the spots, that is, the termes F and G shall not be librated, as the two others B and D; but F shall be lower, and G higher: but yet with lesser difference than in the first Figure. The arch also F N G shall be incurvated, but not so much as the precedent B F D; so that in this position the passages or motions of the spots shall be ascendent from the left side F, towards the right G, and shall be made by curved lines. And imagining the Earth to be constituted in the position diametrically opposite; so that the Hemisphere of the Sun, which was before the occult, may be the apparent, and terminated by the same boundary A B C D, it will be manifestly discerned, that the course of the spots shall be by the arch G S F, beginning from the upper point G, which shall then be likewise from the left hand of the beholder, and going to determine, descending

ascending towards the right, in the point F. What I have hitherto said, being understood, I believe that there remains no difficulty in conceiving how from the passing of the terminator of the Solar Hemispheres by the Poles of the Suns conversion, or neerer or far from the same, do arise all the differences in the apparent courses of the spots; so that by how much the more those Poles shall be remote from the said terminator, by so much the more shall those courses be incurvated, and lesse oblique; whereupon at the same distance, that is, when those Poles are in the section of the Meridian, the incurvation is reduced to the greatest, but the obliquity to the least, that is to *Æquilibrium*, as the second of these three last figures [*viz.* Fig. 5.] demonstrateth. On the contrary, when the Poles are in the terminator, as the first of these three figures [*viz.* Fig. 4.] sheweth the inclination is at the greatest, but the incurvation at the least, and reduced to rectitude. The terminator departing from the Poles, the curvity begins to grow sensible, the obliquity all the way encreasing, and the inclination growing lesser.

These are those admirable and extravagant mutations, that my Guest told me would from time to time appear in the progresses of the Solar spots, if so be it should be true that the annual motion belonged to the Earth, and that the Sun being constituted in the centre of the Ecliptick, were revolved in it self upon an Axis, not erect, but inclined to the Plane of the said Ecliptick.

SAGR. I do now very well apprehend these consequences, and believe that they will be better imprinted in my fancy, when I shall come to reflect upon them, accommodating a Globe to those inclinations, and then beholding them from several places. It now remains that you tell us what followed afterwards touching the event of these imaginary consequences.

The events being observed, were answerable to the predictions.

SALV. It came to passe thereupon, that continuing many several moneths to make most accurate observations, noting down with great exactnesse the courses or transitions of sundry spots at divers times of the year, we found the events punctually to correspond to the predictions.

SAGR. *Simplicius*, if this which *Salviatus* saith be true; (nor can we distrust him upon his word) the *Ptolomeans* and *Aristoteleans* had need of solid arguments, strong conjectures, and well grounded experiments to counterpoise an objection of so much weight, and to support their opinion from its final overthrow.

SIMP. Fair and softly good Sir, for haply you may not yet be got so far as you perswade your self you are gone. And though I am not an absolute master of the subject of that narration

tion given us by *Salviatus*; yet do I not find that my Logick, whilst I have a regard to form, teacheth me, that that kind of argumentation affords me any necessary reason to conclude in favour of the *Copernican* Hypothesis, that is, of the stability of the Sun in the centre of the Zodiack, and of the mobility of the Earth under its circumference. For although it be true, that the said conversion of the Sun, and circonvolution of the Earth being granted, there be a necessity of discerning such and such strange extravagancies as these in the spots of the Sun; yet doth it not follow that arguing *per consequens*, from finding such like unusual accidents in the Sun, one must of necessity conclude the Earth to move by the circumference, and the Sun to be placed in the centre of the Zodiack. For who shall ascertain me that the like irregularities may not as well be visible in the Sun, it being moveable by the Ecliptick, to the inhabitants of the Earth, it being also immoveable in the centre of the same? Unless you demonstrate to me, that there can be no reason given for that appearance, when the Sun is made moveable, and the Earth stable, I will not alter my opinion and belief that the Sun moveth, and the Earth standeth still.

SAGR. *Simplicius* beaveth himself very bravely; and argueth very subtilly in defence of the cause of *Aristotle* and *Ptolemy*; and if I may speak the truth, my thinks that the conversation of *Salviatus*, though it have been but of small continuance, hath much farthered him in discoursing silogistically. An effect which I know to be wrought in others as well as him. But as to finding and judging whether competent reason may be rendered of the apparent exorbitancies and irregularities in the motions of the spots, supposing the Earth to be immoveable, and the Sun moveable, I shall expect that *Salviatus* manifest his opinion to us, for it is very probable that he hath considered of the same, and collected together whatever may be said upon the point.

SALV. I have often thought thereon, and also discoursed thereof with my Friend and Guest afore-named; and touching what is to be produced by Philosophers and Astronomers, in defence of the ancient Systeme, we are on one hand certain, certain I say, that the true and pure *Peripateticks* laughing at such as employ themselves in such, to their thinking, insipid sooleries, will censure all these *Phænomena* to be vain illusions of the Chrystals; and in this manner will with little trouble free themselves from the obligation of studying any more upon the same. Again, as to the Astronomical Philosophers, after we have with some diligence weighed that which may be alledged as a mean between those two others, we have not been able to find out an

Though the annual motion assigned to the Earth answereth to the Phænomena of the solar spots, yet doth it not follow by conversion that from the Phænomena of the spots one may infer the annual motion to belong to the Earth.

It is not possible to find out a way to ascertain the truth of the matter, but by the observation of the spots, and the annual motion of the Earth.

The Pure Peripatetick Philosophers will laugh at the spots and their Phænomena, as illusions of the Chrystals in the Telescope.

answer that sufficeth to satisfie at once the course of the spots, and the discourse of the Mind. I will explain unto you so much as I remember thereof, that so you may judge thereon as seems best unto you.

*If the Earth be
immoveable in the
centre of the Zodi-
ack, there must be
ascribed to the Sun
four several moti-
ons, as is declared
at length.*

Supposing that the apparent motions of the Solar spots are the same with those that have been above declared, and supposing the Earth to be immoveable in the centre of the Ecliptick, in whose circumference let the center of the Sun be placed; it is necessary that of all the differences that are seen in those motions, the causes do reside in the motions that are in the body of the Sun: Which in the first place must necessarily revolve in it self (*i. e.* about its own axis) carrying the spots along therewith; which spots have been supposed, yea and proved to adhere to the Solar superficies. It must secondly be confest, that the Axis of the Solar conversion is not parallel to the Axis of the Ecliptick, that is as much as to say, that it is not perpendicularly erected upon the Plane of the Ecliptick, because if it were so, the courses and exitions of those spots would seem to be made by right lines parallel to the Ecliptick. The said Axis therefore is inclining, in regard the said courses are for the most part made by curve lines. It will be necessary in the third place to grant that the inclination of this Axis is not fixed, and continually extended towards one and the same point of the Universe, but rather that it doth alwayes from moment to moment go changing its direction; for if the pendency should always look towards the self same point, the courses of the spots would never change appearance; but appearing at one time either right or curved, bending upwards or downwards, ascending or descending, they would appear the same at all times. It is therefore necessary to say, that the said Axis is convertible; and is sometimes found to be in the Plane of the circle that is extreme, terminate, or of the visible Hemisphere, I mean at such time as the courses of the spots seem to be made in right lines, and more than ever pendent, which happeneth twice a year; and at other times found to be in the Plane of the Meridian of the Observator, in such sort that one of its Poles falleth in the visible Hemisphere of the Sun, and the other in the occult; and both of them remote from the extreme points, or we may say, from the poles of another Axis of the Sun, which is parallel to the Axis of the Ecliptick; (which second Axis must necessarily be assigned to the Solar Globe) remote, I say, as far as the inclination of the Axis of the revolution of the spots doth import; and moreover that the Pole falling in the apparent Hemisphere, is one while in the superiour, another while in the inferiour part thereof; for that it must be so, the courses themselves do manifestly evince at such time as they are equi-

equilibrated, and in their greatest curvity, one while with their convexity towards the upper part, and another while towards the lower part of the Solar *Discus*. And because those positions are in continuall alteration, making the inclinations and incurvations now greater, now lesser, and sometimes reduce themselves, the first sort to perfect libration, and the second to perfect perpendicularity, it is necessary to assert that the self same Axis of the monethly revolution of the spots hath a particular revolution of its own, whereby its Poles describe two circles about the Poles of another Axis, which for that reason ought (as I have said) to be assigned to the Sun, the semidiameter of which circles answereth to the quantity of the inclination of the said Axis. And it is necessary, that the time of its Period be a year; for that such is the time in which all the appearances and differences in the courses of the spots do return. And that the revolution of this Axis, is made about the Poles of the other Axis parallel to that of the Ecliptick, & not about other points, the greatest inclinations and greatest incurvations, which are always of the same bigness, do clearly prove. So that finally, to maintain the Earth fixed in the centre, it will be necessary to assign to the Sun, two motions about its own centre, upon two several Axes, one of which finisheth its conversion in a year, and the other in lesse than a moneth; which assumption seemeth, to my understanding, very hard, and almost impossible; and this dependeth on the necessity of ascribing to the said Solar body two other motions about the Earth upon different Axes, describing with one the Ecliptick in a year, and with the other forming spirals, or circles parallel to the Equinoctial one every day: whereupon that third motion which ought to be assigned to the Solar Globe about its own centre (I mean not that almost monethly, which carrieth the spots about, but I speak of that other which ought to passe thorow the Axis and Poles of this monethly one) ought not, for any reason that I see, to finish its Period rather in a year, as depending on the annual motion by the Ecliptick, than in twenty four hours, as depending on the diurnal motion upon the Poles of the Equinoctial. I know, that what I now speak is very obscure, but I shall make it plain unto you, when we come to speak of the third motion annual, assigned by *Copernicus*, to the Earth. Now if these four motions, so incongruous with each other, (all which it would be necessary to assign to the self same body of the Sun) may be reduced to one sole and simple motion, assigned the Sun upon an Axis that never changeth position, and that without innovating any thing in the motions for so many other causes assigned to the Terrestrial Globe, may so easily salve so many extravagant appearances in

S f

the

the motions of the Solar spots, it seemeth really that such an Hypothesis ought not to be rejected.

This, *Simplicius*, is all that came into the minds of our friend, and my self, that could be alledged in explanation of this *Phænonenon* by the *Copernicans*, and by the *Ptolomæans*, in defence of their opinions. Do you inferre from thence what your judgment perswades you.

SIMP. I acknowledge my self unable to interpose in so important a decision: And, as to my particular thoughts, I will stand neutral; and yet neverthelesse I hope that a time will come, when our minds being illumin'd by more lofty contemplations than these our humane reasonings, we shall be awakened and freed from that mist which now is so great an hinderance to our sight.

SAGR. Excellent and pious is the counsel taken by *Simplicius*, and worthy to be entertained and followed by all, as that which being derived from the highest wisdom and supremest authority, may onely, with security be received. But yet so far as humane reason is permitted to penetrate, confining my self within the bounds of conjectures, and probable reasons, I will say a little more resolutely than *Simplicius* doth, that amongst all the ingenuous subtilties I ever heard, I have never met with any thing of greater admiration to my intellect, nor that hath more absolutely captivated my judgment, (alwayes excepting pure Geometrical and Arithmetical Demonstrations) than these two conjectures taken, the one from the stations and retrogradations of the five Planets, and the other from these irregularities of the motions of the Solar spots: and because they seem to me so easily and clearly to assign the true reason of so extravagant appearances, shewing as if they were but one sole simple motion, mixed with so many others, simple likewise, but different from each other, without introducing any difficulty, rather with obviating those that accompany the other Hypothesis; I am thinking that I may rationally conclude, that those who contumaciously withstand this Doctrine, either never heard, or never understood, these so convincing arguments.

SALV. I will not ascribe unto them the title either of convincing, or non-convincing; in regard my intention is not, as I have several times told you, to resolve any thing upon so high a question, but onely to propose those natural and Astronomical reasons, which, for the one and other Systeme, may be produced by me, leaving the determination to others; which determination cannot at last, but be very manifest: for one of the two positions being of necessity to be true, and the other of necessity to be false, it is a thing impossible that (alwayes confining our selves within

within the limits of humane doctrine) the reasons alledged for the true Hypothesis should not manifest themselves as concludent as those for the contrary vain and ineffectual.

SAGR. It will be time therefore, that we hear the objections of the little Book of *Conclusions*, or Disquisitions which *Simplicius* did bring with him.

SIMP. Here is the Book, and this is the place where the Author first briefly describeth the Systeme of the world, according to the Hypothesis of *Copernicus*, saying, *Terram igitur una cum Luna, totoque hoc elementari mundo Copernicus*, &c.

SALV. Forbear a little, *Simplicius*, for methinks that this Authour, in this first entrance, shews himself to be but very ill vers'd in the Hypothesis which he goeth about to confute, in regard, he saith that *Copernicus* maketh the Earth, together with the Moon, to describe the * grand Orb in a year moving from East to West; a thing that as it is false and impossible, so was it never affirmed by *Copernicus*, who rather maketh it to move the contrary way, I mean from West to East, that is, according to the order of the Signes; whereupon we come to think the same to be the annual motion of the Sun, constituted immoveable in the centre of the Zodiack. See the too adventurous confidence of this man; to undertake the confutation of anothers Doctrine, and yet to be ignorant of the primary fundamentals; upon which his adversary layeth the greatest and most important part of all the Fabrick. This is a bad beginning to gain himself credit with his Reader; but let us go on.

SIMP. Having explained the Universal Systeme, he beginneth to propound his objections against this annual motion: and the first are these, which he citeth Ironically, and in derision of *Copernicus*, and of his followers, writing that in this phantastical Hypothesis of the World one must necessarily maintain very grosse absurdities; namely, that the Sun, *Venus*, and *Mercury* are below the Earth; and that grave matters go naturally upwards, and the light downwards; and that *Christ*, our Lord and Redeemer, ascended into Hell, and descended into Heaven, when he approached towards the Sun, and that when *Josuah* commanded the Sun to stand still, the Earth stood still, or the Sun moved a contrary way to that of the Earth; and that when the Sun is in *Cancer*, the Earth runneth through *Capricorn*; and that the *Hyemal* (or Winter) Signes make the Summer, and the *Astival* Winter; and that the Stars do not rise and set to the Earth, but the Earth to the Stars; and that the East beginneth in the West, and the West in the East; and, in a word, that almost the whole course of the World is inverted.

SALV. Every thing pleaseth me, except it be his having inter-
 mixed

* I should have told you, that the true name of this concealed Authour is *Christopher Scheinerus*, and its title *Disquisitiones Mathematicae*.

* i.e. the Ecciptick

Instances of a certain Book Ironically propounded against *Copernicus*.

mixed places out of the sacred Scriptures (always venerable, and to be rever'd) amongst these, but two scurrilous fooleries, and attempting to wound with holy Weapons; those who Philosophating in jest, and for divertisement, neither affirm nor deny, but, some presupposals and positions being assumed, do familiarly argue.

SIMP. Truth is, he hath displeased me also, and that not a little; and especially, by adding presently after that, howbeit, the *Copernichists* answer, though but very impertinently to these and such like other reasons, yet can they not reconcile nor answer those things that follow.

SALV. This is worse than all the rest; for he pretendeth to have things more efficacious and concludent than the Authorities of the sacred Leaves; But I pray you, let us reverence them, and passe on to natural and humane reasons: and yet if he give us amongst his natural arguments, things of no more solidity, than those hitherto alleadged, we may wholly decline this undertaking, for I as to my own parricular, do not think it fit to spend words in answering such trifling impertinencies. And as to what he saith, that the *Copernicans* answer to these objections, it is most false, nor may it be thought, that any man should set him self to wast his time so unprofitably.

Supposing the annual motion to belong to the Earth, it followeth, that one fixed Star, is bigger than the whole grand Orb.

SIMP. I concur with you in the same judgement; therefore let us hear the other instances that he brings, as much stronger. And observe here, how he with very exact computations concludeth, that if the grand Orb of the Earth, or the ecliptick, in which *Copernicus* maketh it to run in a year round the Sun, should be as it were, insensible, in respect of the immensitie of the Starry Sphere; according as the said *Copernicus*; saith it is to be supposed, it would be necessary to grant and confirm, that the fixed Stars were remote from us, an unconceivable distance; and that the lesser of them, were bigger than the whole grand Orb afore-said, and some other much bigger than the whole Sphere of *Saturn*; Masses certainly too excessively vast, unimaginable, and incredible.

Tycho his Argument grounded upon a false Hypothesis.

Litigious Lawyers that are entertained in an ill cause, keep close to some excreffion fallen from the adverse party at unawares.

SALV. I have heretofore seen such another objection brought by *Tycho* against *Copernicus*, and this is not the first time that I have discovered the fallacy, or, to say better, the fallacies of this Argumentation, founded upon a most false Hypothesis, and upon a Proposition of the said *Copernicus*, understood by his adversaries, with too punctual a nicity, according to the practise of those pleaders, who finding the flaw to be in the very merit of their cause, keep to some one word, fallen unawares from the contrary partie, and fly out into loud and tedious descants upon that. But for your better information; *Copernicus* having declared those

those admirable consequences which are derived from the Earths annual motion, to the other Planets, that is to say, of the * directions and retrogradations of the three uppermost in particular; he subjoyneth, that this apparent mutation (which is discerned more in Mars than in Jupiter, by reason Jupiter is more remote, and yet lesse in Saturn, by reason it is more remote than Jupiter) in the fixed Stars, did remain imperceptible; by reason of their immense remoteness from us, in comparison of the distances of Jupiter or Saturn. Here the Adversaries of this opinion rise up, and supposing that fore-named imperceptibility of Copernicus, as if it had been taken by him, for a real and absolute thing of nothing, and adding, that a fixed Star of one of the lesser magnitudes, is notwithstanding perceptible, seeing that it cometh under the fence of seeing, they go on to calculate with the intervention of other false assumptions, and concluding that it is necessary by the Copernican Doctrine, to admit, that a fixed Star is much bigger than the whole grand Orb. Now to discover the vanity of this their whole proceeding, I shall shew that a fixed Star of the sixth magnitude, being supposed to be no bigger than the Sun, one may thence conclude with true demonstrations, that the distance of the said fixed Stars from us, cometh to be so great, that the annual motion of the Earth, which causeth so great and notable variations in the Planets, appears scarce observable in them; and at the same time, I will distinctly shew the gross fallacies, in the assumptions of Copernicus his Adversaries.

And first of all, I suppose with the said Copernicus, and also with his opposers, that the Semidiameter of the grand Orb, which is the distance of the Earth from the Sun, containeth 1208 Semidiameters of the said Earth. Secondly, I premise with the allowance aforesaid, and of truth, that the * apparent diameter of the Sun in its mean distance, to be about half a degree, that is, 30. min. prim. which are 1800. seconds; that is, 108000. thirds. And because the apparent Diameter of a fixed Star of the first magnitude, is no more than 5. seconds, that is, 300. thirds, and the Diameter of a fixed Star of the sixth magnitude, 50. thirds, (and herein is the greatest error of the Anti-Copernicans) Therefore the Diameter of the Sun, containeth the Diameter of a fixed Star of the sixth magnitude 2160. times. And therefore if a fixed Star of the sixth magnitude, were supposed to be really equal to the Sun, and not bigger, which is the same as to say, if the Sun were so far removed, that its Diameter should seem to be one of the 2160. parts of what it now appeareth, its distance ought of necessity to be 2160. times greater than now in effect it is, which is as much as to say, that the distance of the fixed Stars of the sixth magnitude, is 2160. Semidiameters of the grand Orb.

* Or progressions.

The apparent diversity of motion in the Planets, is insensible in the fixed Stars.

Supposing that a fixed Star of the sixth magnitude is no bigger than the Sun, the diversity which is so great in the Planets, in the fixed Stars is almost insensible.

The distance of the Sun, containeth 1208 Semid. of the Earth.

* The Diameter of the Sun, half a degree.

The Diameter of a fixed Star of the first magnitude, and of one of the sixth.

The apparent Diameter of the Sun, how much it is bigger than that of a fixed star.

The distance of a fixed star of the sixth magnitude, how much it is, the star being supposed to be equal to the Sun.

In the fixed stars the diversitie of aspect, caused by the grand Orb, is little more then that caused by the Earth in the Sun.

A star of the sixth magnitude, supposed by Tycho and the Authour of the Book of Conclusions, an hundred and six millions of times bigger than needs.

The computation of the magnitude of the fixed Stars, in respect to the grand Orb.

A common error of all the Astronomers, touching the magnitude of the stars.

Orb. And because the distance of the Sun from the Earth, contains by common consent 1208. Semidiameters of the said Earth, and the distance of the fixed Stars (as hath been said) 2160. Semidiameters of the grand Orb, therefore the Semidiameter of the Earth is much greater (that is almost double) in comparison of the grand Orb, than the Semidiameter of the grand Orb, in relation to the distance of the Starry Sphere; and therefore the variation of aspect in the fixed Stars, caused by the Diameter of the grand Orb, can be but little more observable, than that which is observed in the Sun, occasioned by the Semidiameter of the Earth.

SAGR. This is a great fall for the first step.

SALV. It is doubtlesse an error; for a fixed Star of the sixth magnitude, which by the computation of this Authour, ought, for the upholding the proposition of *Copernicus*, to be as big as the whole grand Orb, onely by supposing it equal to the Sun, which Sun is lesse by far, than the hundred and six milionth part of the said grand Orb, maketh the starry Sphere so great and high as sufficeth to overthrow the instance brought against the said *Copernicus*.

SAGR. Favour me with this computation.

SALV. The supputation is easie and short. The Diameter of the Sun, is eleven semidiameters of the Earth, and the Diameter of the grand Orb, contains 2416. of those same semidiameters, by the ascent of both parties; so that the Diameter of the said Orb, contains the Suns Diameter 220. times very near. And because the Spheres are to one another, as the Cubes of their Diameters, let us make the Cube of 220, which is 106480000. and we shall have the grand Orb, an hundred and six millions, four hundred and eighty thousand times bigger than the Sun, to which grand Orb, a star of the sixth magnitude, ought to be equal, according to the assertion of this Authour.

SAGR. The error then of these men, consisteth in being extremely mistaken, in taking the apparent Diameter of the fixed Stars.

SALV. This is one, but not the onely error of them; and indeed, I do very much admire how so many *Astronomers*, and those very famous, as are *Alfagranus*, *Albategnus*, *Tebizius*, and much more modernly the *Tycho's* and *Clavius's*, and in summ, all the predecessors of our *Academician*, should have been so grossly mistaken, in determining the magnitudes of all the Stars, as well fixed as moveable, the two Luminaries excepted out of that number; and that they have not taken any heed to the adventitious irradiations that deceitfully represent them an hundred and more times bigger, than when they are beheld, without those capillitious

ous rayes, nor can this their inadvertency be excused, in regard that it was in their power to have beheld them at their pleasure without those tresses, which is done, by looking upon them at their first appearance in the evening, or their last occultation in the coming on of day; and if none of the rest, yet *Venus*, which oft times is seen at noon day, so small, that one must sharpen the sight in discerning it; and again, in the following night, seemeth a great flake of light, might advertise them of their fallacy; for I will not believe that they thought the true *Discus* to be that which is seen in the obscurest darkneses, and not that which is discerned in the luminous *Medium*: for our lights, which seen by night afar off appear great, and neer at hand shew their true lustre to be terminate and small, might have easily have made them cautious; nay, if I may freely speak my thoughts, I absolutely believe that none of them, no not *Tycho* himself, so accurate in handling Astronomical Instruments, and that so great and accurate, without sparing very great cost in their construction, did ever go about to take and measure the apparent diameter of any Star, the Sun and Moon excepted; but I think, that arbitrarily, and as we say, with the eye, some one of the more antient of them pronounced the thing to be so and so, and that all that followed him afterwards, without more ado, kept close to what the first had said; for if any one of them had applied himself to have made some new proof of the same, he would doubtlesse have discovered the fraud.

SAGR. But if they wanted the Telescope, and you have already said, that our *Friend* with that same Instrument came to the knowledge of the truth, they ought to be excused, and not accused of ignorance.

SALV. This would hold good, if without the Telescope the businesse could not be effected. Its true, that this Instrument by shewing the *Discus* of the Star naked, and magnified an hundred or a thousand times, rendereth the operation much more easie, but the same thing may be done, although not altogether so exactly, without the Instrument, and I have many times done the same, and my method therein was this. I have caused a rope to be hanged towards some Star, and I have made use of the Constellation, called the *Harp*, which riseth between the North and * North-east, and then by going towards, and from the said rope, interposed between me and the Star, I have found the place from whence the thickest of the rope hath just hid the Star from me: this done, I have taken the distance from the eye to the rope, which was one of the sides including the angle that was composed in the eye, and * which insisteth upon the thickest of the rope, and which is like, yea the same with the angle

Venus renders the error of Astronomers in determining the magnitudes of Stars inexcusable.

A way to measure the apparent diameter of a star.

* Rendred in Latine *Corum*, that is to say, North-west.

* i.e. Is subtended by.

angle in the Starry Sphere, that insisteth upon the diameter of the Star, and by the proportion of the ropes thicknesse to the distance from the eye to the rope, by the table of Arches and Chords, I have immediately found the quantity of the angle; using all the while the wonted caution that is observed in taking angles so acute, not to forme the concourse of the visive rayes in the centre of the eye, where they are onely refracted, but beyond the eye, where really the pupils greatnesse maketh them to concur.

SAGR. I apprehend this your cautelous procedure, albeit I have a kind of hesitancy touching the same, but that which most puzzleth me is, that in this operation, if it be made in the dark of night, methinks that you measure the diameter of the irradiated *Discus*, and not the true and naked face of the Star.

SALV. Not so, Sir, for the rope in covering the naked body of the Star, taketh away the rayes, which belong not to it, but to our eye, of which it is deprived so soon as the true *Discus* thereof is hid; and in making the observation, you shall see, how unexpectedly a little cord will cover that reasonable big body of light, which seemed impossible to be hid, unlesse it were with a much broader Screene: to measure, in the next place, and exactly to find out, how many of those thicknesse of the rope interpose in the distance between the said rope and the eye, I take not onely one diameter of the rope, but laying many pieces of the same together upon a Table, so that they touch, I take with a pair of Compasses the whole space occupied by fifteen, or twenty of them, and with that measure I commenlurate the distance before with another smaller cord taken from the rope to the concourse of the visive rayes. And with this sufficiently-exact operation I finde the apparent diameter of a fixed Star of the first magnitude, commonly esteemed to be 2 *min. pri.* and also 3 *min. prim.* by Tycho in his *Astronomical Letters*, cap. 167. to be no more than 5 *seconds*, which is one of the 24. or 36. parts of what they have held it: see now upon what grosse errors their Doctrines are founded.

The diameter of a fixed star of the first magnitude not more than five sec. min.

SAGR. I see and comprehend this very well, but before we passe any further, I would propound the doubt that ariseth in me in the finding the concourse [or interfection] of the visual rayes beyond the eye, when observation is made of objects comprehended between very acute angles; and my scruple proceeds from thinking, that the said concourse may be sometimes more remote, and sometimes lesse; and this not so much, by meanes of the greater or lesser magnitude of the object that is beheld, as because that in observing objects of the same bignesse, it seems to me that the concourse of the rayes, for certain other respects

specis ought to be made more and lesse remote from the eye.

SALV. I see already, whither the apprehension of *Sagredus*, a most diligent observer of Natures secrets, tendeth; and I would lay any wager, that amongst the thousands that have observed Cats to contract and enlarge the pupils of their eyes very much, there are not two, nor haply one that hath observed the like effect to be wrought by the pupils of men in seeing, whilst the *medium* is much or little illumin'd, and that in the open light the circle of the pupil diminisheth considerably: so that in looking upon the face or *Discus* of the Sun, it is reduced to a smallness lesser than a grain of * *Panicum*, and in beholding objects that do not shine, and are in a lesse luminous *medium*, it is enlarged to the bignesse of a * *Lintel* or more; and in summe this expansion and contraction differeth in more than decuple proportion: From whence it is manifest, that when the pupil is much dilated, it is necessary that the angle of the rayes concourse be more remote from the eye; which happeneth in beholding objects little luminated. This is a Doctrine which *Sagredus* hath, just now, given me the hint of, whereby, if we were to make a very exact observation, and of great consequence, we are advertized to make the observation of that concourse in the act of the same, or just such another operation; but in this our case, wherein we are to shew the error of *Astronomers*, this accuratenesse is not necessary: for though we should, in favour of the contrary party, suppose the said concourse to be made upon the pupil it self, it would import little, their mistake being so great. I am not certain, *Sagredus*, that this would have been your objection.

SAGR. It is the very same, and I am glad that it was not altogether without reason; as your concurrence in the same assueth me; but yet upon this occasion I would willingly hear what way may be taken to finde out the distance of the concourse of the visual rayes.

SALV. The method is very easie, and this it is, I take two long* labels of paper, one black, and the other white, and make the black half as broad as the white; then I stick up the white against a wall, and far from that I place the other upon a stick, or other support, at a distance of fifteen or twenty yards, and receding from this, second another such a space in the same right line, it is very manifest, that at the said distance the right lines will concur, that departing from the termes of the breadth of the white piece, shall passe close by the edges of the other label placed in the mid-way; whence it followeth, that in case the eye were placed in the point of the said concourse or intersection, the black slip of paper in the midst would precisely hide the op-

T t

posite

The circle of the pupil of the eye enlargeth and contracteth.

* *Panicum*, a small grain like to Mill, I take it to the same with that called Bird Seed.

* *Scitice*.
How to find the distance of the rays concourse from the pupil.

posite blank, if the sight were made in one onely point; but if we should find, that the edges of the white cartel appear discovered, it shall be a necessary argument that the visual rayes do not issue from one sole point. And to make the white label to be hid by the black, it will be requisite to draw neerer with the eye: Therefore, having approached so neer, that the intermediate label covereth the other, and noted how much the required approximation was, the quantity of that approach shall be the certain measure, how much the true concurrence of the visive rayes, is remote from the eye in the said operation, and we shall moreover have the diameter of the pupil, or of that circlet from whence the visive rayes proceed: for it shall be to the breadth of the black paper, as is the distance from the concurrence of the lines, that are produced by the edges of the papers to the place where the eye standeth, when it first seeth the remote paper to be hid by the intermediate one, as that distance is, I say, to the distance that is between those two papers. And therefore when we would, with exactnesse, measure the apparent diameter of a Star, having made the observation in manner, as aforesaid, it would be necessary to compare the diameter of the rope to the diameter of the pupil; and having found *v.g.* the diameter of the rope to be quadruple to that of the pupil, and the distance of the eye from the rope to be, for example, thirty yards, we would say, that the true concurrence of the lines produced from the ends or extremities of the diameter of the star, by the extremities of the diameter of the rope, doth fall out to be fourty yards remote from the said rope, for so we shall have observed, as we ought, the proportion between the distance of the rope from the concurrence of the said lines, and the distance from the said concurrence to the place of the eye, which ought to be the same that is between the diameter of the rope, and diameter of the pupil.

SAGR. I have perfectly understood the whole businesse, and therefore let us hear what *Simplicius* hath to alledge in defence of the *Anti-Copernicans*.

SIMP. Albeit that grand and altogether incredible inconvenience insisted upon by these adversaries of *Copernicus* be much moderated and abated by the discourse of *Salviatus*, yet do I not think it weakened so, as that it hath not strength enough left to foil this same opinion. For, if I have rightly apprehended the chief and ultimate conclusion, in case, the stars of the sixth magnitude were supposed to be as big as the Sun, (which yet I can hardly think) yet it would still be true, that the grand Orb [or Ecliptick] would occasion a mutation and variation in the starry Sphere, like to that which the semidiameter of the Earth produceth in the Sun, which yet is observable; so that neither that, nor

nor a lesse mutation being discerned in the fixed Stars, methinks that by this means the annual motion of the Earth is destroyed and overthrown.

SALV. You might very well so conclude, *Simplicius*, if we had nothing else to say in behalf of *Copernicus*: but we have many things to alledge that yet have not been mentioned; and as to that your reply, nothing hindereth, but that we may suppose the distance of the fixed Stars to be yet much greater than that which hath been allowed them, and you your self, and whoever else will not derogate from the propositions admitted by *Ptolomy's* sectators, must needs grant it as a thing most requisite to suppose the Starry Sphere to be very much bigger yet than that which even now we said that it ought to be esteemed. For all Astronomers agreeing in this, that the cause of the greater tardity of the Revolutions of the Planets is, the majority of their Spheres, and that therefore *Saturn* is more slow than *Jupiter*, and *Jupiter* than the Sun, for that the first is to describe a greater circle than the second, and that than this later, &c. considering that *Saturn* v.g. the altitude of whole Orb is nine times higher than that of the Sun, and that for that cause the time of one Revolution of *Saturn*, is thirty times longer than that of a conversion of the Sun, in regard that according to the Doctrine of *Ptolomy*, one conversion of the starry Sphere is finished in 36000. years, whereas that of *Saturn* is consummate in thirty, and that of the Sun in one, arguing with a like proportion, and saying, if the Orb of *Saturn*, by reason it is nine times bigger than that of the Sun, revolves in a time thirty times longer, by conversion, how great ought that Orb to be, which revolves 36000. times more slowly? it shall be found that the distance of the starry Sphere ought to be 10800 semidiameters of the grand Orb, which should be full five times bigger than that, which even now we computed it to be, in case that a fixed Star of the sixth magnitude were equal to the Sun. Now see how much lesser yet, upon this account, the variation occasioned in the said Stars, by the annual motion of the Earth, ought to appear. And if at the same rate we would argue the distance of the starry Sphere from *Jupiter*, and from *Mars*, that would give it us to be 15000. and this 27000 semidiameters of the grand Orb, to wit, the first seven; and the second twelve times bigger than what the magnitude of the fixed Star, supposed equal to the Sun, did make it.

SIMP. Methinks that to this might be answered, that the motion of the starry Sphere hath, since *Ptolomy*, been observed not to be so slow as he accounted it; yea, if I mistake not, I have heard that *Copernicus* himself made the Observation:

All Astronomers agree that the greater magnitudes of the Orbes is the cause of the tardity of the conversion.

By another supposition taken from Astronomers, the distance of the fixed Stars is calculated to be 10800 semidiameters of the grand Orb.

By the proportion of Jupiter and of Mars, the Starry Sphere is found to be yet more remote.

T t 2

SALV.

SALV. You say very well ; but you alledge nothing in that which may favour the cause of the *Ptolomeans* in the least, who did never yet reject the motion of 36000. years in the starry Sphere, for that the said tardity would make it too vast and immense. For if that the said immensity was not to be supposed in Nature, they ought before now to have denied a conversion so slow as that it could not with good proportion adapt it self, save onely to a Sphere of monstrous magnitude.

SAGR. Pray you, *Salvatus*, let us lose no more time in proceeding, by the way of these proportions with people that are apt to admit things most dis-proportionate ; so that its impossible to win any thing upon them this way: and what more disproportionate proportion can be imagined than that which these men swallow down, and admit, in that writing, that there cannot be a more convenient way to dispose the Cœlestial Spheres, in order, than to regulate them by the differences of the times of their periods, placing from one degree to another the more slow above the more swift, when they have constituted the Starry Sphere higher than the rest, as being the slowest, they frame another higher still than that, and consequently greater, and make it revolve in twenty four hours, whilst the next below, it moves not round under 36000. years ?

Immense magnitudes and numbers are incomprehensible by our understanding.

SALV. I could wish, *Simplicius*, that suspending for a time the affection that you bear to the followers of your opinion, you would sincerely tell me, whether you think that they do in their minds comprehend that magnitude, which they reject afterwards as incapable for its immensity to be ascribed to the Universe. For I, as to my own part, think that they do not ; But believe, that like as in the apprehension of numbers, when once a man begins to passe those millions of millions, the imagination is confounded, and can no longer form a concept of the same, so it happens also in comprehending immense magnitudes and distances ; so that there intervenes to the comprehension an effect like to that which befallerh the sense ; For whilst that in a serene night I look towards the Stars, I judge, according to sense, that their distance is but a few miles, and that the fixed Stars are not a jot more remote than *Jupiter* or *Saturn*, nay than the Moon. But without more ado, consider the controversies that have past between the Astronomers and Peripatetick Philosophers, upon occasion of the new Stars of *Cassiopeia* and of *Sagittary*, the Astronomers placing them amongst the fixed Stars, and the Philosophers believing them to be below the Moon. So unable is our sense to distinguish great distances from the greatest, though these be in reality many thousand times greater than those. In a word, I ask of thee, O foolish man ! Doth thy imagination comprehend that

that vast magnitude of the Universe, which thou afterwards judgest to be too immense? If thou comprehendest it; wilt thou hold that thy apprehension extendeth it self farther than the Divine Power? wilt thou say, that thou canst imagine greater things than those which God can bring to passe? But if thou apprehendest it not, why wilt thou passe thy verdict upon things beyond thy comprehension?

SIMP. All this is very well, nor can it be denied, but that Heaven may in greatness surpass our imagination, as also that God might have created it thousands of times vaster than now it is; but we ought not to grant any thing to have been made in vain, and to be idle in the Universe. Now, in that we see this admirable order of the Planets, disposed about the Earth in distances proportionate for producing their effects for our advantage, to what purpose is it to interpose afterwards between the sublime Orb of Saturn and the starry Sphere, a vast vacancy, without any star that is superfluous, and to no purpose? To what end? For whose profit and advantage?

SALV. Methinks we arrogate too much to our selves, *Simplicius*, whilst we will have it, that the onely care of us, is the adequate work, and bound, beyond which the Divine Wisdom and Power doth, or disposeth of nothing. But I will not consent, that we should so much shorten its hand, but desire that we may content our selves with an assurance that God and Nature are so employed in the governing of humane affairs, that they could not more apply themselves thereto, although they had no other care than onely that of mankind; and this, I think, I am able to make out by a most pertinent and most noble example, taken from the operation of the Suns light, which whilst it attracteth these vapours, or scorchieth that plant, it attracteth, it scorchieth them, as if it had no more to do; yea, in ripening that bunch of grapes, nay that one single grape, it doth apply it self so, that it could not be more intense, if the sum of all its business had been the only maturation of that grape. Now if this grape receiveth all that it is possible for it to receive from the Sun, not suffering the least injury by the Suns production of a thousand other effects at the same time; it would be either envy or folly to blame that grape, if it should think or wish that the Sun would onely appropriate its rayes to its advantage. I am confident that nothing is omitted by the Divine Providence, of what concerns the government of humane affairs; but that there may not be other things in the Universe, that depend upon the same infinite Wisdom, I cannot, of my self, by what my reason holds forth to me, bring my self to believe. However, if it were not so, yet should I not forbear to believe the reasons laid before me by some

God & Nature
do employ themselves
in caring
for men, as if they
minded nothing
else.

An example of
Gods care of man-
kind taken from
the Sun.

some more sublime intelligence. In the mean time, if one should tell me, that an immenſe ſpace interpoſed between the Orbs of the Planets and the Starry Sphere, deprived of ſtars and idle, would be vain and uſeleſſe, as likewiſe that ſo great an immenſity for receipt of the fixed ſtars, as exceeds our utmoſt comprehension would be ſuperfluous, I would reply, that it is raſhneſſe to go about to make our ſhallow reaſon judg of the Works of God, and to call vain and ſuperfluous, whatſoever thing in the Univerſe is not ſubſervient to us.

It is great raſhneſſe to cenſure that to be ſuperfluous in the Univerſe, which we do not perceive to be made for us.

By depriving Heaven of ſome ſtar, one might come to know what influence it hath upon us.

Many things may be in Heaven, that are inviſible to us.

Great, ſmall, immenſe, &c. are relative terms.

SAGR. Say rather, and I believe you would ſay better, that we know not what is ſubſervient to us; and I hold it one of the greateſt vanities, yea follies, that can be in the World, to ſay, becauſe I know not of what uſe *Jupiter* or *Saturn* are to me, that therefore theſe Planets are ſuperfluous; yea more, that there are no ſuch things in *rerum natura*; when as, oh fooliſh man! I know not ſo much as to what purpoſe the arteries, the griſtles, the ſpleen, the gall do ſerve; nay I ſhould not know that I have a gall, ſpleen, or kidneys, if in many deſected Corps, they were not ſhewn unto me; and then onely ſhall I be able to know what the ſpleen worketh in me, when it comes to be taken from me. To be able to know what this or that Cœleſtial body worketh in me (ſeeing you will have it that all their influences direct themſelves to us) it would be requiſite to remove that body for ſome time; and then whatſoever effect I ſhould find wanting in me, I would ſay that it depended on that ſtar. Moreover, who will preſume to ſay that the ſpace which they call too vaſt and uſeleſſe between *Saturn* and the fixed ſtars, is void of other mundane bodies? Muſt it be ſo, becauſe we do not ſee them? Then the four Medicean Planets, and the companions of *Saturn* came firſt into Heaven, when we began to ſee them, and not before? And by this rule the innumerable other fixed ſtars had no exiſtence before that men did look on them? and the cloudy conſtellations called *Nebulae* were at firſt only white flakes, but afterwards with the Teſcopio we made them to become conſtellations of many lucid and bright ſtars. Oh preſumptuous, rather oh raſh ignorance of man!

SAGR. It's to no purpoſe *Sagredus*, to ſally out any more into theſe unprofitable exaggerations: Let us purſue our intended deſigne of examining the validity of the reaſons alledged on either ſide, without determining any thing, remitting the judgment thereof when we have done, to ſuch as are more knowing. Returning therefore to our natural and humane diſquiſitions, I ſay, that great, little, immenſe, ſmall, &c. are not abſolute, but relative terms, ſo that the ſelf ſame thing compared with divers others, may one while be called immenſe, and another while

while imperceptible, not to say small. This being so, I demand in relation to what the Starry Sphere of *Copernicus* may be called over vast. In my judgment it cannot be compared, or said to be such, unless it be in relation to some other thing of the same kind; now let us take the very least of the same kind, which shall be the Lunar Orb; and if the Starry Orb may be so censured to be too big in respect to that of the Moon, every other magnitude that with like or greater proportion exceedeth another of the same kind, ought to be adjudged too vast, and for the same reason to be denied that they are to be found in the World; and thus an Elephant, and a Whale, shall without more ado be condemned for *Chymera's*, and Poetical fictions, because that the one as being too vast in relation to an Ant, which is a Terrestrial animal, and the other in respect to the *Gudgeon, which is a Fish, and are certainly seen to be *in rerum natura*, would be too immeasurable; for without all dispute, the Elephant and Whale exceed the Ant and Gudgeon in a much greater proportion than the Starry Sphere doth that of the Moon, although we should fancy the said Sphere to be as big as the *Copernican* System maketh it. Moreover, how hugely big is the Sphere of *Jupiter*, or that of *Saturn*, designed for a receptacle but for one single star; and that very small in comparison of one of the fixed? Certainly if we should assign to every one of the fixed stars for its receptacle so great a part of the Worlds space, it would be necessary to make the Orb wherein such innumerable multitudes of them reside, very many thousands of times bigger than that which serveth the purpose of *Copernicus*. Besides, do not you call a fixed star very small, I mean even one of the most apparent, and not one of those which shun our sight; and do we not call them so in respect of the vast space circumscribed? Now if the whole Starry Sphere were one entire lucid body; who is there, that doth not know that in an infinite space there might be assigned a distance so great, as that the said lucid Sphere might from thence shew as little, yea lesse than a fixed star, now appeareth beheld from the Earth. From thence therefore we should then judg that self same thing to be little, which now from hence we esteem to be immeasurably great.

SAGR. Great in my judgment, is the folly of those who would have had God to have made the World more proportionall to the narrow capacities of their reason, than to his immense, rather infinite power.

SIMP. All this that you say is very true; but that upon which the adversary makes a scruple, is, to grant that a fixed star should be not onely equal to, but so much bigger than the Sun; when as they both are particular bodies situate within the
Starry

*Vanity of those
mens discourses who
judg the Starry
Sphere too vast in
the Copernican
Hypothesis.*

* *Spiloncola*, which
is here put for the
least of Fishes.

*The space as-
signed to a fixed
star, is much lesse
than that of a Plan-
et.*

*A star is cal-
led in respect of the
space that environs
it.*

*The whole star-
ry Sphere beheld
from a great dis-
tance might ap-
pear as small as
one single star.*

*Instances of the
Authour of the
Conclusions by way
of interrogation.*

* Or Gulph.

*Answers to the
interrogatories of
the said Authour.*

*The Authour
of the Conclusions
confound and
contradicts him-
self in his interro-
gations.*

*Interrogatories
put to the Au-
thour of the Con-
clusions, by which
the weaknesse of
his is made appear.*

Starry Orb : "And indeed in my opinion this Authour very
"pertinently questioneth and asketh : To what end, and
"for whose sake are such huge machines made ? Were they
"produced for the Earth, for an inconsiderable point ? And
"why so remote ? To the end they might seem so very small,
"and might have no influence at all upon the Earth ? To
"what purpose is such a needlesse monstrous immensity be-
"tween them and Saturn ? All those assertions fall to the
"ground that are not upheld by probable reasons.

SALV. I conceive by the questions which this person asketh,
that one may collect ; that in case the Heavens, the Stars, and
the quantity of their distances and magnitudes which he hath
hitherto held, be let alone, (although he never certainly fancied
to himself any conceivable magnitude thereof) he perfectly dis-
cerns and comprehends the benefits that flow from thence to the
Earth, which is no longer an inconsiderable thing ; nor are they
any longer so remote as to appear so very small, but big enough to
be able to operate on the Earth ; and that the distance between
them and Saturn is very well proportioned, and that he, for all
these things, hath very probable reasons ; of which I would glad-
ly have heard some one : but being that in these few words he
confounds and contradicts himself, it maketh me think that he
is very poor and ill furnished with those probable reasons, and
that those which he calls reasons, are rather fallacies, or dreams
of an over-weening fancy. For I ask of him, whether these Ce-
lestial bodies truly operate on the Earth, and whether for the
working of those effects they were produced of such and such
magnitudes, and disposed at such and such distances, or else
whether they have nothing at all to do with Terrene matters. If
they have nothing to do with the Earth ; it is a great folly for us
that are Earth-born, to offer to make our selves arbitrators of
their magnitudes, and regulators of their local dispositions, see-
ing that we are altogether ignorant of their whole businesse and
concerns ; but if he shall say that they do operate, and that they
are directed to this end, he doth affirm the same thing which a
little before he denied, and praiseth that which even now he
condemned, in that he said, that the Celestial bodies situate so
far remote as that they appear very small, cannot have any in-
fluence at all upon the Earth. But, good Sir, in the Starry Sphere
pre-established at its present distance, and which you did ac-
knowledg to be in your judgment, well proportioned to have an
influence upon these Terrene bodies ; many stars appear very
small, and an hundred times as many more are wholly invisible
unto us (which is an appearing yet lesse than very small)
therefore it is necessary that (contradicting your self) you do
now

now deny their operation upon the the Earth; or else that (still contradicting your self) you grant that their appearing very small doth not in the least lessen their influence; or else that (and this shall be a more sincere and modest concession) you acknowledg and freely confesse, that our passing judgment upon their magnitudes and distances is a vanity, not to say presumption or rashnesse.

SIMP. Truth is, I my self did also, in reading this passage perceive the manifest contradiction; in saying, that the Stars (if one may so speak) of *Copernicus* appearing so very small, could not operate on the Earth, and not perceiving that he had granted an influence upon the Earth to those of *Ptolomy*, and his sectators, which appear not only very small, but are, for the most part, very invilible.

SALV. But I proceed to another consideration: What is the reason, doth he say, why the stars appear so little? Is it haply, because they seem so to us? Doth not he know, that this cometh from the Instrument that we employ in beholding them, to wit, from our eye? And that this is true, by changing Instru- ment, we shall see them bigger and bigger, as much as we will. And who knows but that to the Earth, which beholdeth them without eyes, they may not shew very great, and such as in reality they are? But it's time that, omitting these trifles, we come to things of more moment; and therefore I having already demonstrated these two things: First, how far off the Firmament ought to be placed to make, that the grand Orb causeth no greater difference than that which the Terrestrial Orb occasioneth in the remotenesse of the Sun; And next, how likewise to make that a star of the Firmament appear to us of the same bignesse, as now we see it, it is not necessary to suppose it bigger than the Sun; I would know whether *Tycho*, or any of his adherents hath ever attempted to find out, by any means, whether any appearance be to be discovered in the starry Sphere, upon which one may the more resolutely deny or admit the annual motion of the Earth.

SAGR. I would answer for them, that there is not, no nor is there any need there should; seeing that it is *Copernicus* himself that saith, that no such diversity is there: and they, arguing *ad hominem*, admit him the same; and upon this assumption they demonstrate the improbability that followeth thereupon, namely, that it would be necessary to make the Sphere so immense, that a fixed star, to appear unto us as great as it now seems, ought of necessity to be of so immense a magnitude, as that it would exceed the bignesse of the whole grand Orb, a thing, which notwithstanding, as they say, is altogether incredible.

V V

SALV.

That remote objects appear so small, is the defect of the eye, as is demonstrated.

Tycho nor his followers ever attempted to see whether there are any appearances in the Firmament for or against the annual motion.

Astronomers, perhaps, have not known what appearances ought to follow upon the annual motion of the Earth.

Copernicus understood not some things for want of Instruments.

Tycho and others argue against the annual motion, from the invariable elevation of the Pole.

** Christophorus Rothmannus.*

SALV. I am of the same judgment, and verily believe that they argue *contra hominem*; studying more to defend another man, than desiring to come to the knowledge of the truth. And I do not only believe, that none of them ever applied themselves to make any such observation, but I am also uncertain, whether any of them do know what alteration the Earths annual motion ought to produce in the fixed stars, in case the starry Sphere were not so far distant, as that in them the said diversity, by reason of its minuity dis-appeareth; for their surceasing that inquisition, and referring themselves to the meer assertion of *Copernicus*, may very well serve to convict a man, but not to acquit him of the fact: For its possible that such a diversity may be, and yet not have been sought for; or that either by reason of its minuity, or for want of exact Instruments it was not discovered by *Copernicus*; for though it were so, this would not be the first thing, that he either for want of Instruments, or for some other defect hath not known; and yet he proceeding upon other solid and rational conjectures, affirmeth that, which the things by him not discovered do seem to contradict: for, as hath been said already, without the Telescope, neither could *Mars* be discerned to increase 60. times; nor *Venus* 40. more in that than in this position; yea, their differences appear much lesse than really they are: and yet nevertheless it is certainly discovered at length, that those mutations are the same, to an hair that the *Copernican* Systeme required. Now it would be very well, if with the greatest accuratenesse possible one should enquire whether such a mutation as ought to be discoverable in the fixed stars, supposing the annual motion of the Earth, would be observed really, and in effect, a thing which I verily believe hath never as yet been done by any; done, said I? no, nor haply (as I said before) by many well understood how it ought to be done. Nor speak I this at randome, for I have heretofore seen a certain Manuscript of one of these *Anti-Copernicans*, which said, that there would necessarily follow, in case that opinion were true, a continual rising and falling of the Pole from six moneths to six moneths, according as the Earth in such a time; by such a space as is the diameter of the grand Orb, retireth one while towards the North, and another while towards the South; and yet it seemed to him reasonable, yea necessary, that we, following the Earth, when we were towards the North should have the Pole more elevated than when we are towards the South. In this very error did one fall that was otherwise a very skilful Mathematician, & a follower of *Copernic.* as *Tycho* relateth in his **Progymnasma* pag. 684. which said, that he had observed the Polar altitude to vary, and to differ in Summer from what it is in Winter: and because *Tycho* denieth the merit of

of the cause, but findeth no fault with the method of it; that is, denieth that there is any mutation to be seen in the altitude of the Pole, but doth not blame the inquisition, for not being adapted to the finding of what is sought, he thereby sheweth, that he also esteemed the Polar altitude varied, or not varied every six moneths, to be a good testimony to disprove or inferre the annual motion of the Earth.

SIMP. In truth, *Salviatus*, my opinion also tells me, that the same must necessarily ensue: for I do not think that you will deny me, but that if we walk only 60. miles towards the North, the Pole will rise unto us a degree higher, and that if we move 60. miles farther Northwards, the Pole will be elevated to us a degree more; &c. Now if the approaching or receding 60. miles onely, make so notable a change in the Polar altitudes, what alteration would follow, if the Earth and we with it, should be transported, I will not say 60. miles, but 60. thousand miles that way.

SALV. It would follow (if it should proceed in the same proportion) that the Pole shall be elevated a thousand degrees. See, *Simplicius*, what a long rooted opinion can do. Yea, by reason you have fixed it in your mind for so many years, that it is Heaven that revolveth in twenty four hours, and not the Earth, and that consequently the Poles of that Revolution are in Heaven, and not in the Terrestrial Globe, cannot now, in an hours time shake off this habituated conceipt, and take up the contrary, fancying to your self, that the Earth is that which moveth, only for so long time as may suffice to conceive of what would follow, thereupon should that lye be a truth. If the Earth *Simplicius*, be that which moveth in its self in twenty four hours, in it are the Poles, in it is the Axis, in it is the Equinoctial, that is, the grand Circle, described by the points, equidistant from the Poles, in it are the infinite Parallels; bigger and lesser described by the points of the superficies more and lesse distant from the Poles, in it are all these things; and not in the starry Sphere; which, as being immoveable, wants them all, and can only by the imagination be conceived to be therein, prolonging the Axis of the Earth so far, till that determining, it shall mark our two points placed right over our Poles, and the plane of the Equinoctial being extended, it shall describe in Heaven a circle like it self. Now if the true Axis, the true Poles, the true Equinoctial, do not change in the Earth so long as you continue in the same place of the Earth, and though the Earth be transported, as you do please, yet you shall not change your habitude either to the Poles, or to the circles, or to any other Earthly thing; and this because, that that transposition being common to you and to all Terrestrial things;

*A motion where
it is common, is as
if it never were.*

things; and that motion where it is common, is as if it never were; and as you change not habitude to the Terrestrial Poles (habitude I say, whether that they rise, or descend) so neither shall you change position to the Poles imagined in Heaven; always provided that by Celestial Poles we understand (as hath been already defined) those two points that come to be marked out by the prolongation of the Terrestrial Axis unto that length. 'Tis true those points in Heaven do change, when the Earths transportment is made after such a manner, that its Axis cometh to passe by other and other points of the immoveable Celestial Sphere; but our habitude thereunto changerh not, so as that the second should be more elevated to us than the first. If any one will have one of the points of the Firmament, which do answer to the Poles of the Earth to ascend, and the other to descend, he must walk along the Earth towards the one, receding from the other, for the transportment of the Earth; and with it us our selves, (as I told you before) operates nothing at all.

An example fitted to prove that the altitude of the Pole ought not to vary by means of the Earths annual motion.

* *Corfia*, the bank or bench on which slaves sit in a Galley.

SAGR. Permit me, I beseech you *Salviatus*, to make this a little more clear by an example, which although grosse, is accommodated to this purpose. Suppose your self, *Simplicius*, to be aboard a Ship, and that standing in the Poop, or Hind-deck; you have directed a Quadrant, or some other Astronomical Instrument, towards the top of the Top-gallant-Mast, as if you would take its height, which suppose it were *v. gr.* 40. degrees, there is no doubt, but that if you walk along the Hatches towards the Mast 25. or 30. paces; and then again direct the said Instrument to the same Top-Gallant-Top. You shall find its elevation to be greater; and to be encreased *v. gr.* 10. degrees; but if instead of walking those 25. or 30. paces towards the Mast, you stand still at the Sterne; and make the whole Ship to move thitherwards; do you believe that by reason of the 25. or 30. paces that it had past, the elevation of the Top-Gallant-Top would shew 10. degrees encreased?

SIMP. I believe and know that it would not gain an hairs breadth in the passing of 30. paces, nor of a thousand, no nor of an hundred thousand miles; but yet I believe withal that looking through the sights at the Top and Top-Gallant, if I should find a fixed Star that was in the same elevation, I believe I say, that, holding still the Quadrant, after I had sailed towards the star 60. miles, the eye would meet with the top of the said Mast, as before; but not with the star, which would be elevated to me one degree.

SAGR. Then you do not think that the sight would fall upon that point of the Starry Sphere, that answereth to the direction of the Top-Gallant Top?

SIMP.

SIMP. No: For the point would be changed, and would be beneath the star first observed.

SAGR. You are in the right. Now like as that which in this example answereth to the elevation of the Top-Gallant-Top, is not the star, but the point of the Firmament that lyeth in a right line with the eye, and the said top of the Mast, so in the case exemplified, that which in the Firmament answers to the Pole of the Earth, is not a star, or other fixed thing in the Firmament; but is that point in which the Axis of the Earth continued streight out, till it cometh thither doth determine, which point is not fixed, but obeyeth the mutations that the Pole of the Earth doth make. And therefore Tycho, or who ever else that did alledg this objection, ought to have said that upon that same motion of the Earth, were it true, one might observe some difference in the elevation and depression (not of the Pole, but) of some fixed star toward that part which answereth to our Pole.

SIMP. I already very well understand the mistake by them committed; but yet therefore (which to me seems very great) of the argument brought on the contrary is not lessened, supposing relation to be had to the variation of the stars, and not of the Pole; for if the moving of the Ship but 60. miles, make a fixed star rise to me one degree, shall I not find alike, yea and very much greater mutation, if the Ship should sail towards the said star for so much space as is the Diameter of the Grand Orb, which you affirm to be double the distance that is between the Earth and Sun?

SAGR. Herein *Simplicius*, there is another fallacy, which, truth is, you understand, but do not upon the sudden think of the same, but I will try to bring it to your remembrance: Tell me therefore; if when after you have directed the Quadrant to a fixed star, and found *v. g.* its elevation to be 40. degrees, you should without stirring from the place, incline the side of the Quadrant, so as that the star might remain elevated above that direction, would you thereupon say that the star had acquired greater elevation?

SIMP. Certainly no: For the mutation was made in the Instrument and not in the Observer, that did change place, moving towards the same.

SAGR. But if you sail or walk along the surface of the Terrestrial Globe, will you say that there is no alteration made in the said Quadrant, but that the same elevation is still retained in respect of the Heavens, so long as you your self do not incline it, but let it stand at its first constitution?

SIMP. Give me leave to think of it. I would say without more ado, that it would not retain the same, in regard the progressive

Upon the annual motion of the Earth, alteration may ensue in some fixed star, not in the Pole.

The equivoke of those who believe that in the annual motion great mutations are to be made about the elevation of a fixed star, is confuted.

gresse I make is not *in plano*, but about the circumference of the Terrestrial Globe; which at every step changeth inclination in respect to Heaven, and consequently maketh the same change in the Instrument which is erected upon the same.

SAGR. You say very well: And you know withal, that by how much the bigger that circle shall be upon which you move, so many more miles you are to walk, to make the said star to rise that same degree higher; and that finally if the motion towards the star should be in a right line, you ought to move yet farther, than if it were about the circumference of never so great a circle?

The right line, and circumference of an infinite circle, are the same thing.

SALV. True: For in short the circumference of an infinite circle, and a right line are the same thing.

SAGR. But this I do not understand, nor as I believe, doth *Simplicius* apprehend the same; and it must needs be concealed from us under some mystery, for we know that *Salviatus* never speaks at random, nor proposeth any Paradox, which doth not break forth into some conceit, not trivial in the least. Therefore in due time and place I will put you in mind to demonstrate this, that the right line is the same with the circumference of an infinite circle, but at present I am unwilling that we should interrupt the discourse in hand. Returning then to the case, I propose to the consideration of *Simplicius*, how the accession and recession that the Earth makes from the said fixed star which is neer the Pole can be made as it were by a right line, for such is the Diameter of the Grand Orb, so that the attempting to regulate the elevation and depression of the Polar star by the motion along the said Diameter, as if it were by the motion about the little circle of the Earth, is a great argument of but little judgment.

SIMP. But we continue still unsatisfied, in regard that the said small mutation that should be therein, would not be discerned; and if this be *null*, then must the annual motion about the Grand Orb ascribed to the Earth, be *null* also.

SAGR. Here now I give *Salviatus* leave to go on, who as I believe will not overpasse the elevation and depression of the Polar star or any other of those that are fixed as *null*, although not discovered by any one, and affirmed by *Copernicus* himself to be, I will not say *null*, but unobservable by reason of its minuity.

Inquiry is made what mutations, & in what stars, are to be discovered, by means of the annual motion of the Earth.

SALV. I have already said above, that I do not think that any one did ever set himself to observe, whether in different times of the year there is any mutation to be seen in the fixed stars, that may have a dependance on the annual motion of the Earth, and added withal, that I doubted least haply some might never have under-

understood what those mutations are ; and amongst what stars they should be discerned ; therefore it would be necessary that we in the next place narrowly examine this particular. My having onely found written in general terms that the annual motion of the Earth about the Grand Orb , ought not to be admitted , because it is not probable but that by means of the same there would be discovered some apparent mutation in the fixed stars, and not hearing say what those apparent mutations ought to be in particular , and in what stars ; maketh me very reasonably to infer that they who rely upon that general position , have not understood , no nor possibly endeavoured to understand , how the businesse of these mutations goeth , nor what things those are which they say ought to be seen. And to this judgment I am the rather induced , knowing that the annual motion ascribed by *Copernicus* to the Earth , if it should appear sensible in the Starry Sphere , is not to make apparent mutations equal in respect to all the stars ; but those appearances ought to be made in some greater , in others lesser , and in others yet lesser ; and lastly , in others absolutely nothing at all , by reason of the vast magnitude that the circle of this annual motion is supposed to be of. As for the mutations that should be seen , they are of two kinds ; one is the said stars changing apparent magnitude , and the other their variation of altitudes in the Meridian. Upon which necessarily followeth the mutation of risings and settings , and of their distances from the Zenith, &c.

SAGR. Methinks I see preparing for me such a skean of these revolutions , that I wish it may never be my task to dis-intangle them , for to confesse my infirmity to *Salviatus* , I have sometimes thought thereon , but could never find the * Lay-band of it ; and I speak not so much of this which pertains to the fixed stars ; as of another more terrible labour which you bring to my remembrance by maintaining these Meridian Altitudes ; Ortive Latitudes and distances from the Vertex, &c. And that which puzzleth my brains , ariseth from what I am now about to tell you. *Copernicus* supposeth the Starry Sphere immoveable , and the Sun in the centre thereof immoveable also. Therefore every mutation which seemeth unto us to be made in the Sun or in the fixed stars , must of necessity befall the Earth and be ours. But the Sun riseth and declineth in our Meridian by a very great arch of almost 47. degrees ; and by arches yet greater and greater ; varieth its Ortive and Occidial Latitudes in the oblique Horizons. Now how can the Earth ever incline and elevate so notably to the Sun , and nothing at all to the fixed stars , or so little , that it is not to be perceived ? This is that knot which could never get thorow my * Loom-Combe ; and if you shall untie

Astronomers having omitted to insinuate what alterations those are that may be derived from the annual motion of the Earth , do thereby testify that they never rightly understood the same.

The mutations of the fixed stars ought to be in some greater , in others lesser , and in others nothing at all.

* *Bandola* that end of a skean wherewith housewives fasten their hankes of yarn , thread or silk.

The grand difficulty in Copernicus his Doctrine , is that which concerns the Phenomena of the Sun and fixed stars.

* *Pettine* , it is the stay in a Weavers Loom , that permitteeth no knot or snarle to passe it , called by them the Combe of the Loom.

untie it, I shall hold you for more than an *Alexander*.

SALV. These are scruples worthy of the ingenuity of *Sagredus*, and this doubt is so intricate, that even *Copernicus* himself almost despaired of being able to explain the same, so as to render it intelligible, which we see as well by his own confession of its obscurity, as also by his, at two several times, taking two different ways to make it out. And, I ingenuously confesse that I understood not his explanations, till such time as another method more plain and manifest, had rendred it intelligible; and yet neither was that done without a long and laborious application of my thoughts to the same.

Aristotles argument against the Ancients, who held that the Earth was a Planet.

SIMP. *Aristotle* saw the same scruple, and makes use thereof to oppose certain of the Ancients, who held that the Earth was a Planet; against whom he argueth, that if it were so, it would follow that it also, as the rest of the Planets, should have a plurality of motions, from whence would follow these variations in the risings and settings of the fixed stars, and likewise in the Meridian Altitudes. And in regard that he propoundeth the difficulty, and doth not answer it, it must needs be, if not impossible, at least very difficult to be resolved.

The annual motion made by the centre of the Earth under the Ecliptick and the diurnal motion made by the Earth about its own centre.

The axis of the Earth continueth alwayes parallel to it self, and describeth a Cylindrical superficies, inclining to the grand Orb.

SALV. The stress and strength of the knot rendereth the solution thereof more commendable and admirable; but I do not promise you the same at this time, and pray you to dispense with me therein till too morrow, and for the present we will go considering and explaining those mutations and differences that by means of the annual motion ought to be discerned in the fixed stars, like as even now we said, for the explication whereof certain preparatory points offer themselves, which may facilitate the answer to the grand objection. Now reassuming the two motions ascribed to the Earth (two I say, for the third is no motion, as in its place I will declare) that is the annual and diurnal, the first is to be understood to be made by the centre of the Earth in or about the circumference of the grand Orb, that is of a very great circle described in the plain of the fixed and immutable Ecliptick; the other, namely the diurnal, is made by the Globe of the Earth in it self about its own centre, and own Axis, not erect, but inclined to the Plane of the Ecliptick, with the inclination of 23. degrees and an half, or thereabouts, the which inclination is maintained all the year about, and that which ought especially to be observed, is alwayes situate towards the same point of Heaven: in so much that the Axis of the diurnal motion doth alwayes remain parallel to it self; so that if we imagine that same Axis to be continued out until it reach the fixed stars, whilst the centre of the Earth is encircling the whole Ecliptick in a year, the said Axis describeth the superficies

ficies of an oblique Cylinder, which hath for one of its bases the said annual circle, and for the other a like circle imaginarily described by its extremity, or, (if you will) Pole, amongst the fixed stars. And this same cylinder is oblique to the Plane of the Ecliptick, according to the inclination of the Axis that describeth it, which we have said to be 23 degrees and an half, the which continuing perpetually the same (save onely, that in many thousands of years it maketh some very small mutation, which nothing importeth in our present businesse) causeth that the Terrestrial Globe doth never more incline or elevate, but still conserveth the same state without mutation. From whence ensueth, that as to what pertaineth to the mutations to be observed in the fixed stars dependant on the sole annual motion, the same shall happen to any point whatsoever of the Earths surface, as befalleth unto the centre of the Earth it self; and therefore in the present explanations we will make use of the centre, as if it were any whatsoever point of the superficies. And for a more facile understanding of the whole, let us design the same in lineal figures: And first of all let us describe in the Plane of the Ecliptick the circle A N B O [in Fig. 7.] and let us understand the points A and B, to be the extrems towards the North and South; that is, the beginning of [or entrance into] Cancer or Capricorn, and let us prolong the Diameter A B, indeterminately, by D and C towards the Starry Sphere. I say now in the first place, that none of the fixed stars placed in the Ecliptick, shall ever vary elevation, by reason of any whatsoever mutation made by the Earth along the said Plane of the Ecliptick, but shall alwayes appear in the same superficies, although the Earth shall approach and recede as great a space as is that of the diameter of the Grand Orb, as may plainly be seen in the said figure. For whether the Earth be in the point A or in B, the star C alwayes appeareth in the same line A B C; although the distance B C, be lesse than A C, by the whole diameter A B. The most therefore that can be discovered in the star C, and in any other placed in the Ecliptick, is the augmented or diminished apparent magnitude, by reason of the approximation or recession of the Earth.

SAGR. Stay a while I pray you, for I meet with a certain scruple, which much troubleth me, and it is this; That the star C may be seen by the same line A B C, as wel when the Earth is in A, as when it is in B, I understand very well; as also furthermore I apprehend that the same would happen in all the points of the line A B, so long as the Earth should passe from A to B by the said line; but it passing thither, as is to be supposed, by the arch A N B, it is manifest that when it shall be in the point

X x

The Orb of the Earth never inclineth, but is immutably the same.

The fixed stars placed in the Ecliptick never elevate nor descend, on account of the annual motion, but yet approach and recede.

Objections against the Earths annual motion taken from the fixed stars placed in the Ecliptick.

point N, and in any other except those two A and B, the said star shall no longer be observed in the line A B; but in others. So that, if the appearing under several lines ought to cause apparent mutations, some difference must needs appear in this case. Nay more, I will speak it with that Philosophical freedom, which ought to be allowed amongst Philosophick friends; methinks that you, contradicting your self, deny that now; which but even now to our admiration, you proved to be really true, and considerable; I mean that which happeneth in the Planets, and particularly in the three superiour ones, that being constantly in the Ecliptick, or very near unto it, do not only shew themselves one while near unto us, and another while remote; but so deformed in their regular motions, that they seem sometimes immoveable, and sometimes many degrees retrograde; and all upon no other occasion than the annual motion of the Earth.

SALV. Though by a thousand accidents I have been heretofore assured of the wittinesse of *Sagredus*, yet I had a desire by this one experiment more to ascertain me of what I may expect from his ingenuity, and all this for my own interest, for in case my Propositions stand but proof against the hammer and furnace of his judgment, I shall be confident that they will abide the * test of all Touch-stones. I say therefore that I had purposely dissembled this objection; but yet not with any intent to deceive you, and to put any fallshood upon you, as it might have happened if the objection by me disguised, and by you overlooked, had been the same in effect as it seemed to be in appearance, that is, really valid and conclusive; but it is not so; nay I rather suspect that to try me; you make as if you did not see its nullity. But I will herein be too hard for you, and force from your tongue, that which you would so artificially conceal; and therefore tell me, what that thing should be; whereby you come to know the station and retrogradation of the Planets, which is derived from the annual motion, and which is so great, that at least some foot-steps of such an effect ought to appear in the stars of the Ecliptick?

SAGR. This demand of yours containeth two questions, to which it is necessary that I make reply; the first relates to the imputation which you lay upon me of a Dissembler; the other concerneth that which may appear in the stars, &c. As to the first, I will say with your permission, that it is not true, that I have dissembled my knowing the nullity of that objection; and to assure you of the same, I now tell you that I very well understand the nullity thereof.

SALV. But yet I do not understand how it can be, that you
spake

* Or will prove
of good alloy.

Spake not friendly, when you said you did not know that same fallacy which you now confesse that you know very well.

SAGR. The very confession of knowing it may assure you that I did not dissemble, when I said that I did not understand it; for if I had had a mind, and would dissemble, who could hinder me from continuing in the same simulation, and denying still that I understand the fallacy? I say therefore that I understood not the same, at that time, but that I do now at this present apprehend it, for that you have prompted my intellect, first by telling me resolutely that it is *null*, and then by beginning to question me so at large what thing that might be, whereby I might come to know the station and retrogradation of the Planets; and because this is known by comparing them with the fixed stars, in relation to which, they are seen to vary their motions, one while towards the West, and another towards the East, and sometimes to abide immoveable; and because there is not any thing above the Starry Sphere, immensely more remote from us, and visible unto us, wherewith we may compare our fixed stars; therefore we cannot discover in the fixed stars any foot-steps of what appeareth to us in the Planets. This I believe is the substance of that which you would force from me.

SALV. It is so, with the addition moreover of your admirable ingenuity; and if with half a word I did open your eyes, You by the like have remembred me that it is not altogether impossible, but that sometime or other something observable may be found amongst the fixed stars, by which it may be gathered wherein the annual conversion resides, so as that they also no less than the Planets and Sun it self, may appear in judgment to bear witness of that motion, in favour of the Earth; for I do not think that the stars are spread in a spherical superficies equally remote from a common centre, but hold, that their distances from us are so various, that some of them may be twice and thrice as remote as others; so that if with the Telescope one should observe a very small star neer to one of the bigger, and which therefore was very exceeding high, it might happen, that some sensible mutation might fall out between them, correspondent to that of the superiour Planets. And so much shall serve to have spoken at this time touching the stars placed in the Ecliptick. Let us now come to the fixed stars, placed out of the Ecliptick, and let us suppose a great circle crect upon [*i. e. at right angles* to] the Plane of the *same, and let it, for example, be a circle that in the Starry Sphere answers to the Solstitial Colure, and let us mark it CEH [*in Fig. 8.*] which shall happen to be withal a Meridian, and in it we will take a star without the Ecliptick, which let be E. Now this star will indeed vary its elevation

X x 2

on

The station, direction and retrogradation of the Planets is known, in relation to the fixed stars.

An Indice in the fixed stars like to that which is seen in the Planets, is an argument of the Earth's annual motion.

The fixed stars without the Ecliptick elevate and descend more or less, according to their distance from the said Ecliptick, i. e. of the Ecliptick.

on upon the Earths motion ; for from the Earth in A it shall be seen according to the ray A E, with the elevation of the angle E A C ; but from the Earth placed in B, it shall be seen according to the ray B E, with the elevation of the angle E B C, bigger than the other E A C, that being extern, and this intern and opposite in the triangle E A B, the distance therefore of the star E from the Ecliptick, shall appear changed ; and likewise its altitude in the Meridian shall become greater in the position B, than in the place A, according as the angle E B C exceeds the angle E A C, which excess is the quantity of the angle A E B : For in the triangle E A B, the side A B being continued to C, the exterior angle E B C (as being equal to the two interior and opposite E and A) exceedeth the said angle A, by the quantity of the angle E. And if we should take another star in the same Meridian, more remote from the Ecliptick, as for instance the star H, the diversity in it shall be greater by being observed from the two stations A and B, according as the angle A H B is greater than the other E ; which angle shall encrease continually according as the observed star shall be farther and farther from the Ecliptick, till that at last the greatest mutation will appear in that star that should be placed in the very Pole of the Ecliptick. As for a full understanding thereof we thus demonstrate. Suppose the diameter of the Grand Orb to be A B, whose centre [in the same Figure] is G, and let it be supposed to be continued out as far as the Starry Sphere in the points D and C, and from the centre G let there be erected the Axis of the Ecliptick G F, prolonged till it arrive at the said Sphere, in which a Meridian D F C is supposed to be described, that shall be perpendicular to the Plane of the Ecliptick ; and in the arch F C any points H and E, are imagined to be taken, as places of fixed stars : Let the lines F A, F B, A H, H G, H B, A E, G E, B E, be conjoynd. And let the angle of difference, or, if you will, the Parallax of the star placed in the Pole F, be A F B, and let that of the star placed in H, be the angle A H B, and let that of the star in E, be the angle A E B. I say, that the angle of difference of the Polar star E, is the greatest, and that of the rest, those that are nearer to the greatest are bigger than the more remote ; that is to say, that the angle F is bigger than the angle H, and this bigger than the angle E. Now about the triangle F A B, let us suppose a circle to be described. And because the angle F is acute, (by reason that its base A B is lesse than the diameter D C, of the semicircle D F C) it shall be placed in the greater portion of the circumscribed circle cut by the base A B. And because the said A B is divided in the midst, and at right angles by F G, the centre of the circumscribed

bed circle shall be in the line FG , which let be the point I ; and because that of such lines as are drawn from the point G , which is not the centre, unto the circumference of the circumscribed circle, the biggest is that which passeth by the centre, GF shall be bigger than any other that is drawn from the point G , to the circumference of the said circle; and therefore that circumference will cut the line GH (which is equal to the line GF) and cutting GH , it will also cut AH . Let it cut it in L , and conjoin the line LB . These two angles, therefore, AFB and ALB shall be equal, as being in the same portion of the circle circumscribed. But ALB external, is bigger than the internal H ; therefore the angle F is bigger than the angle H . And by the same method we might demonstrate the angle H to be bigger than the angle E , because that of the circle described about the triangle AHB , the centre is in the perpendicular GF , to which the line GH is nearer than the line GE , and therefore the circumference of it cutteth GE , and also AE , whereupon the proposition is manifest. We will conclude from hence, that the difference of appearance, (which with the proper term of art, we might call the Parallax of the fixed stars) is greater, or lesse, according as the Stars observed are more or lesse adjacent to the Pole of the Ecliptick, so that, in conclusion of those Stars that are in the Ecliptick it self, the said diversity is reduced to nothing. In the next place, as to the Earths accession by that motion to, or recession from the Stars, it appeareth to, and recedeth from those that are in the Ecliptick, the quantity of the whole diameter of the grand Orb, as we did see even now; but that accession or recession to, or from the stars about the Pole of the Ecliptick, is almost nothing; and in going to and from others, this difference groweth greater, according as they are neerer to the Ecliptick. We may, in the third place, know, that the said difference of Aspect groweth greater or lesser, according as the Star observed shall be neerer to us, or farther from us. For if we draw another Meridian, lesse distant from the Earth; as for example, this DFI [in Fig. 7.] a Star placed in F , and seen by the same ray AFE , the Earth being in A , would, in case it should be observed from the Earth in B , appear according to the ray BF , and would make the angle of difference, namely, BFA , bigger than the former AEB , being the exterior angle of the triangle BFE .

SAGR. With great delight, and also benefit have I heard your discourse; and that I may be certain, whether I have rightly understood the same, I shall give you the summe of the Conclusions in a few words. As I take it, you have explained to us the different appearances, that by means of the Earths annual motion,

The Earth approacheth or recedeth from the fixed stars of the Ecliptick, the quantity of the Diameter of the Grand Orb.

The stars neerer to us make greater differences than the more remote.

The Epilogus of the Phenomena of the fixed stars caused by the annual motion of the Earth.

tion, may be by us observed in the fixed stars to be of two kinds: The one is, that of their apparent magnitudes varied, according as we, transported by the Earth, approach or recede from the same: The other (which likewise dependeth on the same accession and recession) their appearing unto us in the same Meridian, one while more elevated, and another while lesse. Moreover, you tell us (and I understand it very well) that the one and other of these mutations are not made alike in all the stars, but in some greater, and in others lesser, and in others not at all. The accession and recession whereby the same star ought to appear, one while bigger, and another while lesser, is insensible, and almost nothing in the stars neer unto the pole of the Ecliptick, but is greatest in the stars placed in the Ecliptick it self, and indifferent in the intermediate: the contrary happens in the other difference, that is, the elevation or depression of the stars placed in the Ecliptick is nothing at all, greatest in those neereft to the Pole of the said Ecliptick, and indifferent in the intermediate. Besides, both these differences are more sensible in the Stars neereft to us, in the more remote lesse sensible, and in those that are very far distant wholly disappear. This is, as to what concerns my self; it remaineth now, as I conceive, that something be said for the satisfaction of *Simplicius*, who, as I believe, will not easily be made to over-passe those differences, as insensible that are derived from a motion of the Earth so vast, and from a mutation that transports the Earth into places twice as far distant from us as the Sun.

SIMP. Truth is, to speak freely, I am very loth to confesse, that the distance of the fixed Stars ought to be such, that in them the fore-mentioned differences should be wholly imperceptible.

In objects far remote, and luminous, a small approach or recession is imperceptible.

SALV. Do not throw your self into absolute despair, *Simplicius*, for there may perhaps yet some qualification be found for your difficulties. And first, that the apparent magnitude of the stars is not seen to make any sensible alteration, ought not to be judged by you a thing improbable, in regard you see the guesses of men in this particular to be so grossely erroneous, especially in looking upon splendid objects; and you your self beholding v. g. a lighted Torch at the distance of 200 paces, if it approach nearer to you 3. or 4. yards, do you think that it will shew any whit encreased in magnitude? I for my part should not perceive it certainly, although it should approach 20. or 30. yards nearer; nay it hath sometimes happened that in seeing such a light at that distance I know not how to resolve whether it came towards me, or retreated from me, when as it did in reality approach nearer to me. But what need I speak of this? If the self same accession and recession (I speak of a distance twice

twice as great as that from the Sun to us) in the star of *Saturn* is almost totally imperceptible, and in *Jupiter* not very observable, what shall we think of the fixed stars, which I believe you will not scruple to place twice as far off as *Saturn*? In *Mars*, which for that it is nearer to us —

SIMP. Pray Sir, put your self to no farther trouble in this particular, for I already conceive that what hath been spoken touching the unaltered apparent magnitude of the fixed stars may very well come to passe, but what shall we say of the other difficulty that proceeds from not perceiving any variation in the mutation of aspect?

SALV. We will say that which peradventure may satisfy you also in this particular. And to make short, would you not be satisfied if there should be discovered in the stars face mutations that you think ought to be discovered, in case the annual motion belonged to the Earth?

SIMP. I should so doubtless, as to what concerns this particular.

SALV. I could wish you would say that in case such a difference were discovered, nothing more would remain behind, that might render the mobility of the Earth questionable. But although yet that should not sensibly appear, yet is not its mobility removed, nor its immobility necessarily proved, it being possible, (as *Copernicus* affirmeth) that the immense distance of the Starry Sphere rendereth such very small *Phænomena* unobservable; the which as already hath been said, may possibly not have been hitherto so much as sought for, or if sought for, yet not sought for in such a way as they ought, to wit, with that exactness which to so minute a punctuality would be necessary, which exactness is very difficult to obtain, as well by reason of the deficiency of Astronomical Instruments, subject to many alterations, as also through the fault of those that manage them with less diligence than is requisite. A necessary argument how little credit is to be given to those observations may be deduced from the differences which we find amongst Astronomers in assigning the places, I will not say, of the new Stars or Comets, but of the fixed stars themselves, even to the altitudes of the very Poles, in which, most an end, they are found to differ from one another many minutes. And to speak the truth, who can in a Quadrant, or Sextant, that at most shall have its side * 3. or 4. yards long, ascertain himself in the incidence of the perpendicular, or in the direction of the sights, not to erre two or three minutes, which in its circumference shall not amount to the breadth of a grain of Mylet? Besides that, it is almost impossible, that the Instrument should be made, and kept with absolute exactness. *Ptolomey* sheweth

If in the fixed stars one should discover any annual mutation, the motion of the Earth would be undeniable.

It is proved what small credit is to be given to Astronomical Instruments in minute observations.

* Braccia Italian.

* Or Mill.

*Protony did not
trust to an Instru-
ment made by Ar-
chimedes.*

*Instruments of
Tycho made with
great expence.*

*What Instru-
ments are apt for
most exact obser-
vation.*

* Italian braces.

*An exquisite
observation of the
approach and de-
parture of the Sun
from the Summer
Solstice.*

*A place accom-
modated for the
observation of the
fixed stars, as to
what concerns the
annual motion of
the Earth.*

sheweth his distrust of a Spherical Instrument composed by *Archimedes* himself to take the Suns ingression into the *Æquinoctial*.

SIMP. But if the Instruments be so suspicious, and the observations so dubious, how can we ever come to any certainty of things; or free our selves from mistakes? I have heard strange things of the Instruments of *Tycho* made with extraordinary cost, and of his singular diligence in observations.

SALV. All this I grant you; but neither one nor other of these is sufficient to ascertain us in a businesse of this importance. I desire that we may make use of Instruments greater by far, and by far certainer than those of *Tycho*, made with a very small charge; the sides of which are of 4. 6. 20. 30. and 50. miles, so as that a degree is a mile broad, a minute prim. 50 * yards, a second but little lesse than a yard, and in short we may without a farthing expence procure them of what bignesse we please. I being in a Countrey Seat of mine near to *Florence*, did plainly observe the Suns arrival at, and departure from the Summer Solstice, whilst one Evening at the time of its going down it appeared upon the top of a Rock on the Mountains of *Pietrapana*, about 60. miles from thence, leaving discovered of it a small streak or filament towards the North, whose breadth was not the hundredth part of its Diameter; and the following Evening at the like setting, it shew'd such another part of it, but notably more small, a necessary argument, that it had begun to recede from the Tropick; and the regression of the Sun from the first to the second observation, doth not import doubtlesse a second minute in the East. The observation made afterwards with an exquisite Telescope, and that multiplyeth the *Discus* of the Sun more than a thousand times, would prove easie, and with all delightful. Now with such an Instrument as this, I would have observations to be made in the fixed stars, making use of some of those wherein the mutation ought to appear more conspicuous, such as are (as hath already been declared) the more remote from the *Ecliptick*; amongst which the *Harp* a very great star, and near to the Pole of the *Ecliptick*, would be very proper in Countries far North; proceeding according to the manner that I shall shew by and by, but in the use of another star; and I have already fancied to my self a place very well adapted for such an observation. The place is an open Plane, upon which towards the North there riseth a very eminent Mountain, in the apex or top whereof is built a little Chappel, situate East and West, so as that the ridg of its Roof may intersect at right angles, the meridian of some building standing in the Plane. I will place a beam parallel to the said ridg, or top of the Roof,

and

and distant from it a yard or thereabouts. This being placed, I will seek in the Plain the place from whence one of the stars of *Charls's* Waine, in passing by the Meridian, cometh to hide it self behind the beam so placed, or in case the beam should not be so big as to hide the star, I will finde a station where one may see the said beam to cut the said star into two equal parts; an effect that with an *exquisite Telescope may be perfectly discerned. And if in the place where the said accident is discovered, there were some building, it will be the more commodious; but if not, I will cause a Pole to be stuck very fast in the ground, with some standing mark to direct where to place the eye anew, when ever I have a mind to repeat the observation. The first of which observations I will make about the Summer Solstice, to continue afterwards from Moneth to Moneth, or when I shall so please, to the other Solstice; with which observation one may discover the elevation and depression of the star, though it be very small. And if in that operation it shall happen, that any mutation shall discover it self, what and how great benefit will it bring to Astronomy? Seeing that thereby, besides our being assured of the annual motion, we may come to know the grandure and distance of the same star.

SAGR. I very well comprehend your whole proceedings; and the operation seems to me so easie, and so commodious for the purpose, that it may very rationally be thought, that either *Copernicus* himself, or some other Astronomer had made trial of it.

SALV. But I judg the quite contrary, for it is not probable; that if any one had experimented it, he would not have mentioned the event, whether it fell out in favour of this, or that opinion; besides that, no man that I can find, either for this, or any other end, did ever go about to make such an Observation; which also without an exact Telescope could but badly be effected.

SIMP. I am fully satisfied with what you say. But seeing that it is a great while to night, if you desire that I shall passe the same quietly, let it not be a trouble to you to explain unto us those Problems, the declaration whereof you did even now request might be deferred until too morrow. Be pleased to grant us your promised indulgence, and, laying aside all other discourses, proceed to shew us, that the motions which *Copernicus* assigns to the Earth being taken for granted, and supposing the Sun and fixed stars immoveable, there may follow the same accidents touching the elevations and depressions of the Sun, touching the mutations of the Seasons, and the inequality of dayes and nights, &c. in the self same manner, just as they are with

Y y

fa-

facility apprehended in the *Ptolomaick* Systeme.

The Copernican Systeme difficult to be understood, but easie to be effected.

Necessary prepositions for the better conceiving of the consequences of the Earths motion.

SALV. I neither ought, nor can deny any thing that *Sagredus* shall request: And the delay by me desired was to no other end, save only that I might have time once again to methodize those prefatory points, in my fancy, that serve for a large and plain declaration of the manner how the forenamed accidents follow, as well in the *Copernican* position, as in the *Ptolomaick*: nay, with much greater facility and simplicity in that than in this. Whence one may manifestly conceive that Hypothesis to be as easie to be effected by nature, as difficult to be apprehended by the understanding: yet nevertheless, I hope by making use of another kind of explanation, than that used by *Copernicus*, to render likewise the apprehending of it somewhat lesse obscure. Which that I may do, I will propose certain suppositions of themselves known and manifest, and they shall be these that follow.

First, I suppose that the Earth is a spherical body, turning round upon its own Axis and Poles, and that each point assigned in its superficies, describeth the circumference of a circle, greater or lesser, according as the point assigned shall be neerer or farther from the Poles: And that of these circles the greatest is that which is described by a point equidistant from the said Poles, and all these circles are parallel to each other; and *Parallels* we will call them.

Secondly, The Earth being of a Spherical Figure, and of an opaque substance, it is continually illuminated by the Sun, according to the half of its surface, the other half remaining obscure, and the boundary that distinguisheth the illuminated part from the dark being a grand circle, we will call that circle the *terminator of the light*.

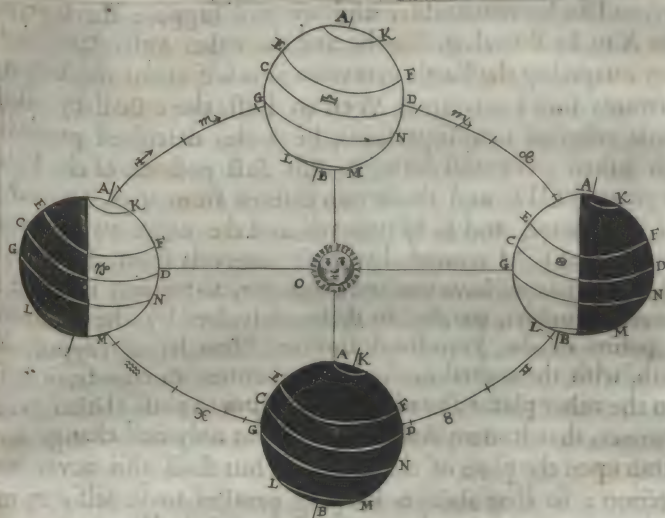
Thirdly, If the Circle that is terminator of the light should passe by the Poles of the Earth, it would cut (being a grand and principal circle) all the parallels into equal parts; but not passing by the Poles, it would cut them all in parts unequal, except only the circle in the middle, which, as being a grand circle will be cut into equal parts.

Fourthly, The Earth turning round upon its own Poles, the quantities of dayes and nights are terminated by the arches of the *Parallels*, intersected by the circle, that is, the terminator of the light, and the arch that is situate in the illuminated Hemisphere describeth the length of the day, and the remainder is the quantity of the night.

A plain Scheme representing the Copernican Hypothesis, and its consequences.

These things being presupposed, for the more clear understanding of that which remains to be said, we will lay it down in a Figure. And first, we will draw the circumference of a circle, that shall represent unto us that of the grand Orb described

bed in the plain of the Ecliptick, and this we will divide into four equal parts with the two diameters *Capricorn Cancer*, and *Libra Aries*, which, at the same time, shall represent unto us the four Cardinal points, that is, the two Solstices, and the two Equinoxials; and in the centre of that circle we will place the Sun O, fixed and immoveable.



Let us next draw about the four points, *Capricorn*, *Cancer*, *Libra* and *Aries*, as centres, four equal circles, which represent unto us the Earth placed in them at four several times of the year. The which, with its centre, in the space of a year, passeth through the whole circumference, *Capricorn*, *Aries*, *Cancer*, *Libra*, moving from East to West, that is, according to the order of the Signes. It is already manifest, that whilst the Earth is in *Capricorn*, the Sun will appear in *Cancer*, and the Earth moving along the arch *Capricorn Aries*, the Sun will seem to move along the arch *Cancer Libra*, and in short, will run thorow the *Zodiack* according to the order of the Signes, in the space of a year; and by this first assumption, without all question, full satisfaction is given for the Sun's apparent annual motion under the Ecliptick. Now, coming to the other, that is, the diurnal motion of the Earth in it self, it is necessary to establish its Poles and its Axis, the which must be understood not to be erect perpendicularly upon the plain of the Ecliptick, that is, not to be parallel to the Axis of the grand Orb, but declining from a right angle 23 degrees and an half, or thereabouts, with its North Pole towards the

The Sun's annual motion, how it comes to passe, according to *Capricorn*,

Y y 2

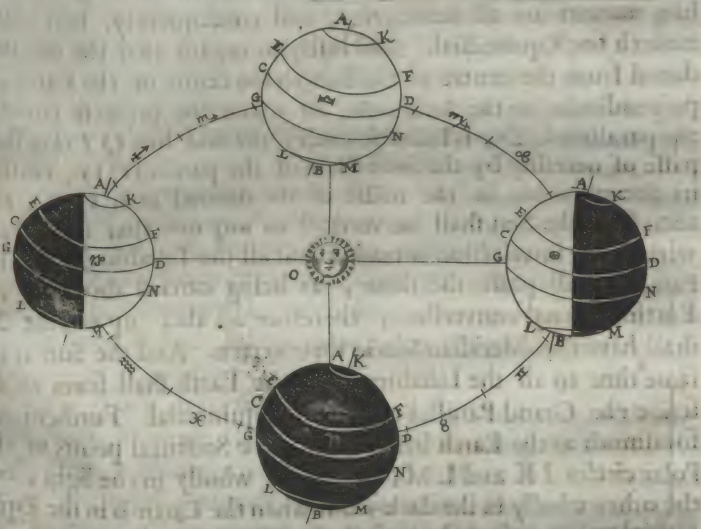
the Axis of the grand Orb, the Earths centre being in the Solstitial point of Capricorn. Supposing therefore the Terrestrial Globe to have its centre in the point Capricorn, we will describe its Poles and Axis A B, inclined upon the diameter Capricorn Cancer 23 degrees and an half; so that the angle A Capricorn Cancer cometh to be the complement of a Quadrant or Radius, that is, 66 degrees and an half; and this inclination must be understood to be immutable, and we will suppose the superiour Pole A to be Boreal, or North, and the other Austral, or South. Now imagining the Earth to revolve in it self about the Axis A B in twenty four hours, from West to East, there shall by all the points assigned in its superficies, be circles described parallel to each other. We will draw, in this first position of the Earth, the greatest C D, and those two distant from it gr. 23. and an half, E F above, and G M beneath, and the other two extreame ones I K and L M remote; by those intervals from the Poles A and B; and as we have marked these five, so we may imagine innumerable others, parallel to these, described by the innumerable points of the Terrestrial surface. Next let us suppose the Earth, with the annual motion of its centre, to transerre it self into the other places already marked; but to passe thither in such a manner, that its own Axis A B shall not only not change inclination upon the plain of the Ecliptick, but shall also never vary direction; so that alwayes keeping parallel to it self, it may continually tend towards the same part of the Universe, or, if you will, of the Firmament, whereas, if we do but suppose it prolonged, it will, with its extreame termes, designe a Circle parallel and equal to the grand Orb, Libra Capricorn Aries Cancer, as the superiour base of a Cylinder described by it self in the annual motion above the inferiour base, Libra Capricorn Aries Cancer. And therefore this immutability of inclination continuing, we will design these other three figures about the centres Aries, Cancer, and Libra, alike in every thing to that first described about the centre Capricorn. Now we will consider the first figure of the Earth, in which, in regard the Axis A B is declined from perpendicularity upon the diameter Capricorn Cancer 23 degrees and an half, towards the Sun O, and the arch A I being also 23 degrees and an half, the illumination of the Sun will illustrate the Hemisphere of the Terrestrial Globe exposed towards the Sun (of which, in this place, half is to be seen) divided from the obscure part by the Terminator of the light I M, by which the parallel C D, as being a grand circle, shall come to be divided into equal parts, but all the rest into parts unequal; being that the terminator of the light I M passeth not by their Poles A B, and the parallel I K, together with all the rest described

described within the same, and neerer to the pole A, shall wholly be included in the illuminated part; as on the contrary, the opposite ones towards the Pole B, contained within the parallel L M, shall remain in the dark. Moreover, the arch A I being equal to the arch F D, and the arch A F, common to them both, the two arches I K F and A F D shall be equal, and each a quadrant or 90 degrees. And because the whole arch I F M is a semicircle, the arch F M shall be a quadrant, and equal to the other F K I; and therefore the Sun O shall be in this state of the Earth vertical to one that stands in the point F. But by the revolution diurnal about the standing Axis A B, all the points of the parallel E F passe by the same point F: and therefore in that same day the Sun, at noon, shall be vertical to all the inhabitants of the Parallel E F, and will seem to them to describe in its apparent motion the circle which we call the Tropick of Cancer. But to the inhabitants of all the Parallels that are above the parallel E F, towards the North pole A, the Sun declineth from their *Vertex* or Zenith towards the South; and on the contrary, to all the inhabitants of the Parallels that are beneath E F, towards the Equinoctial C D, and the South Pole B, the Meridian Sun is elevated beyond their *Vertex* towards the North Pole A. Next, it is visible that of all the Parallels, only the greatest C D is cut in equal parts by the Terminator of the light I M. But the rest, that are beneath and above the said grand circle, are all intersected in parts unequal: and of the superiour ones, the semidiurnal arches, namely those of the part of the Terrestrial surface, illustrated by the Sun, are bigger than the seminocturnal ones that remain in the dark: and the contrary befalls in the remainder, that are under the great one C D, towards the pole B, of which the semidiurnal arches are lesser than the seminocturnal. It is likewise apparently manifest, that the differences of the said arches go augmenting, according as the Parallels are neerer to the Poles, till such time as the parallel I K comes to be wholly in the part illuminated, and the inhabitants thereof have a day of twenty four hours long, without any night; and on the contrary, the Parallel L M, remaining all in obscurity, hath a night of twenty four hours, without any day. Come we next to the third Figure of the Earth, placed with its centre in the point Cancer, where the Sun seemeth to be in the first point of Capricorn. We have already seen very manifestly, that by reason the Axis A B doth not change inclination, but continueth parallel to it self, the aspect and situation of the Earth is the same to an hair with that in the first Figure; save onely that that Hemisphere which in the first was illuminated by the Sun, in this remaineth obtenebrated, and that cometh to be luminous, which in the

the first was tenebrous : whereupon that which happened before concerning the differences of dayes and nights, touching the dayes being greater or lesser than the nights, now falls out quite contrary. And first, we see, that whereas in the first Figure the circle I K was wholly in the light, it is now wholly in the dark; and the opposite arch L M is now wholly in the light, which was before wholly in the dark. Of the parallels between the grand circle C D, and the Pole A, the semidiurnal arches are now lesser than the seminocturnal, which before were the contrary. Of the others likewise towards the Pole B, the semidiurnal arches are now bigger than the seminocturnal, the contrary to what happened in the other position of the Earth. We now see the Sun made vertical to the inhabitants of the Tropick G N, and to be depressed towards the South, with those of the Parallel E F, by all the arch E C G, that is, 47 degrees ; and in summe, to have passed from one to the other Tropick, traversing the Equinoctial, elevating and declining in the Meridians the said space of 47 degrees. And all this mutation is derived not from the inclination or elevation of the Earth, but on the contrary, from its not inclining or elevating at all ; and in a word, by continuing always in the same position, in respect of the Universe, onely with turning about the Sun situate in the midst of the said plane, in which it moveth it self about circularly with its annual motion. And here is to be noted an admirable accident, which is, that like as the Axis of the Earth conserving the same direction towards the Universe, or we may say, towards the highest Sphere of the fixed stars, causeth the Sun to appear to elevate and incline so great a space, namely, for 47 degrees, and the fixed Stars to incline or elevate nothing at all ; so, on the contrary, if the same Axis of the Earth should maintain it self continually in the same inclination towards the Sun, or, if you will, towards the Axis of the Zodiack, no mutation would appear to be made in the Sun about its elevating or declining, whereupon the inhabitants of one and the same place would alwayes have one and the same difference of dayes and nights, and one and the same constitution of Seasons, that is, some alwayes Winter ; others alwayes Summer, others Springs, &c. but, on the contrary, the alterations in the fixed Stars would appear very great, as touching their elevation, and inclination to us, which would amount to the same 47 degrees. For the understanding of which let us return to consider the position of the Earth, in its first Figure, where we see the Axis A B, with the superiour Pole A, to incline towards the Sun; but in its third Figure, the same Axis having kept the same direction towards the highest Sphere, by keeping parallel to it self, inclines no longer towards the Sun with its superiour Pole A, but on

*An admirable
accident depending
on the not inclining
of the Earths axis*

on the contrary reclines from its former position gr. 47. and inclineth towards the opposite part, so that to restore the same inclination of the said Pole A towards the Sun, it would be requisite by turning round the Terrestrial Globe, according to the circumference A C B D, to transport it towards E those same gr. 47. and for so many degrees, any whatsoever fixed star observed in the Meridian, would appear to be elevated, or inclined. Let us come now to the explanation of that which remains, and let us consider the Earth placed in the fourth Figure, that is, with its centre in the first point of Libra; upon which the Sun will appear in the beginning of Aries. And because the Axis of



the Earth, which in the first Figure is supposed to be inclined upon the diameter Capricorn Cancer, and therefore to be in that same plane, which cutting the plane of the grand Orb, according to the line Capricorn Cancer, was erected perpendicularly upon the same, transposed into the fourth Figure, and maintained, as hath alwayes been said, parallel to it self, it shall come to be in a plane in like manner erected to the superficies of the Grand Orbe, and parallel to the plane, which at right angles cuts the same superficies, according to the diameter Capricorn Cancer. And therefore the line which goeth from the centre of the Sunne to the centre of the Earth, that is, O Libra, shall be perpendicular to the Axis B A: but the same line which goeth from the centre of the Sunne to the centre of the Earth, is also alwayes perpendicular to the circle

circle that is the Terminator of the light ; therefore this same circle shall passe by the Poles A B in the fourth figure , and in its plain the Axis A B shall fall , but the greatest circle passing by the Poles of the Parallels , divideth them all in equal parts ; therefore the arches I K , E F , C D , G N , L M , shall be all semicircles , and the illumin'd Hemisphere shall be this which looketh towards us , and the Sun ; and the Terminator of the light shall be one and the same circle A C B D , and the Earth being in this place shall make it Equinoctial to all its Inhabitants. And the same happeneth in the second figure , where the Earth having its illuminated Hemisphere towards the Sun , sheweth us the other that is obscure , with its nocturnal arches , which in like manner are all semicircles , and consequently , here also it maketh the Equinoctial. And lastly in regard that the line produced from the centre of the Sun to the centre of the Earth , is perpendicular to the Axis A B , to which the greatest circle of the parallels C D , is likewise erect , the said line *Q Libra* shall passe of necessity by the same Plain of the parallel C D , cutting its circumference in the midst of the diurnal arch C D ; and therefore the Sun shall be vertical to any one that shall stand where that intersection is made ; but all the Inhabitants of that Parallel shall passe the same , as being carried about by the Earths diurnal conversion ; therefore all thes upon that day shall have the Meridian Sun in their vertex. And the Sun at the same time to all the Inhabitants of the Earth shall seem to describe the Grand Parallel called the Equinoctial. Furthermore , forasmuch as the Earth being in both the Solstitial points of the Polar circles I K and L M , the one is wholly in the light , and the other wholly in the dark ; but when the Earth is in the Equinoctial points , the halves of those same polar circles are in the light , the remainder of them being in the dark ; it should not be hard to understand , how that the Earth *v. gr.* from *Cancer* (where the parallel I K is wholly in the dark) to *Leo* , one part of the parallel towards the point I , beginneth to enter into the light , and that the Terminator of the light I M beginneth to retreat towards the Pole A B , intersecting the circle A C B D no longer in I M , but in two other points falling between the terms I A and M B , of the arches I A and M B ; whereupon the Inhabitants of the circle begin to enjoy the light , and the other Inhabitants of the circle L M to partake of night. And thus you see that by two simple motions made in times proportionate to their bignesses , and not contrary to one another , but performed , as all others that belong to moveable mundane bodies , from West to East assigned to the Terrestrial Globe , adequate reasons are rendred of all those *Phænomena* or appearances , for the accomodating of which

which to the stability of the Earth it is necessary (forsaking that Symetry which is observed to be between the velocities and magnitudes of moveables) to ascribe to a Sphere, vast above all others, an unconceivable celerity; whilst the other lesser Spheres move extream slowly; and which is more, to make that motion contrary to all their motions; and, yet again to adde to the improbability, to make that superiour Sphere forcibly to transport all the inferior ones along with it contrary to their proper inclination. And here I refer it to your judgment to determine which of the two is the most probable.

SAGR. To me, as far as concerneth sense, there appeareth no small difference betwixt the simplicity and facility of operating effects by the means assigned in this new constitution, and the multiplicity, confusion, and difficulty, that is found in the ancient and commonly received Hypothesis. For if the Universe were disposed according to this multiplicity, it would be necessary to renounce many Maxims in Philosophy commonly received by Philosophers, as for instance, That Nature doth not multiply things without necessity; and, That She makes use of the most facile and simple means in producing her effects; and, That She doth nothing in vain, and the like. I do confesse that I never heard any thing more admirable than this, nor can I believe that Humane Understanding ever penetrated a more sublime speculation. I know not what *Simplicius* may think of it.

Axiomes commonly admitted by all Philosophers.

SIMP. These (if I may speak my judgment freely) do seem to me some of those Geometrical subtilties which *Aristotle* finds fault with in *Plato*; when he accuseth him that by his too much studying of Geometry he forsook solid Philosophy; and I have known and heard very great *Peripatetick* Philosophers to dissuade their Scholars from the Study of the Mathematicks, as those that render the wit cavilous, and unable to philosophate well; an Institute diametrically contrary to that of *Plato*, who admitted none to Philosophy, unlesse he was first well entered in Geometry.

Aristotle taxeth Plato for being too studious of Geometry.

SALV. I commend the policy of these your *Peripateticks*, in dehorting their Disciples from the Study of Geometry; for that there is no art more commodious for detecting their fallacies; but see how they differ from the Mathematical Philosophers, who much more willingly converse with those that are well versed in the commune *Peripatetick* Philosophy, than with those that are destitute of that knowledg, who for want thereof cannot distinguish between doctrine and doctrine. But passing by this, tell me I beseech you, what are those extravagancies and those too affected subtilties that make you think this *Copernican* System the lesse plausible?

Peripatetick Philosophers condemn the Study of Geometry, and why.

Z z

SIMP.

*Four several
motions assigned to
the Earth.*

*The motion of
descent belongs not
to the terrestrial
Globe, but to its
parts.*

*The annual and
diurnal motion are
compatible in the
Earth.*

*Every pensil and
librated body car-
ried round in the
circumference of a
circle, acquireth of
it self a motion in
it self contrary to
that.*

SIMP. To tell you true, I do not very well know; perhaps, because I have not so much as learnt the reasons that are by *Ptolemy* produced, of those effects, I mean of those stations, retrogradations, accessions, recessions of the Planets; lengthenings and shortenings of dayes, changes of seasons, &c. But omitting the consequences that depend on the first suppositions, I find in the suppositions themselves no small difficulties; which suppositions, if once they be overthrown, they draw along with them the ruine of the whole fabrick. Now forasmuch as because the whole module of *Copernicus* seemeth in my opinion to be built upon infirm foundations, in that it relyeth upon the mobility of the earth, if this should happen to be disproved, there would be no need of farther dispute. And to disprove this, the Axiom of *Aristotle* is in my judgement most sufficient, That of one simple body, one sole simple motion can be natural: but here in this case, to the Earth, a simple body, there are assigned 3. if not 4. motions, and all very different from each other. For besides the right motion, as a grave body towards its centre, which cannot be denied it, there is assigned to it a circular motion in a great circle about the Sun in a year, and a vertiginous conversion about its own centre in twenty four hours. And that in the next place which is more exorbitant, & which happily for that reason you pass over in silence, there is ascribed to it another revolution about its own centre, contrary to the former of twenty four hours, and which finisheth its period in a year. In this my understanding apprehendeth a very great contradiction.

SALV. As to the motion of descent, it hath already been concluded not to belong to the Terrestrial Globe which did never move with any such motion, nor never shall do; but is (if there be such a thing) that propension of its parts to reunite themselves to their whole. As, in the next place, to the Annual motion, and the Diurnal, these being both made towards one way, are very compatible, in the same manner just as if we should let a Ball trundle downwards upon a declining superficies, it would in its descent along the same spontaneously revolve in it self. As to the third motion assigned it by *Copernicus*, namely about it self in a year, onely to keep its Axis inclined and directed towards the same part of the Firmament, I will tell you a thing worthy of great consideration: namely *ut tantum abest* (although it be made contrary to the other annual) it is so far from having any repugnance or difficulty in it, that naturally and without any moving cause, it agreeth to any whatsoever suspended and librated body, which if it shall be carried round in the circumference of a circle, immediate of it self, it acquireth a conversion about its own centre, contrary to that which carrieth it about, and of such

such velocity, that they both finish one revolution in the same time precisely. You may see this admirable, and to our purpose accommodate experience, if putting in a Bason of water a Ball that will swim; and holding the Bason in your hand, you turn round upon your toe, for you shall immediatly see the Ball begin to revolve in it self with a motion, contrary to that of the Bason, and it shall finish its revolution, when that of the Bason it shall finish. Now what other is the Earth than a pensil Globe librated in tenuous and yielding aire, which being carried about in a year along the circumference of a great circle, must needs acquire, without any other mover, a revolution about its own centre, annual, and yet contrary to the other motion in like manner annual? You shall see this effect I say, but if afterwards you more narrowly consider it, you shall find this to be no real thing, but a meer appearance; and that which you think to be a revolution in it self, you will find to be a not moving at all; but a continuing altogether immoveable in respect of all that which without you, and without the vessel is immoveable: for if in that Ball you shall make some mark, and consider to what part of the Room where you are, or of the Field, or of Heaven it is situate, you shall see that mark in yours, and the vessels revolution to look alwayes towards that same part; but comparing it to the vessel and to your self that are moveable, it will appear to go altering its direction, and with a motion contrary to yours, and that of the vessel, to go seeking all the points of its circumscription; so that with more reason you and the bason may be said to turn round the immoveable Ball, than that it moveth round in the bason. In the same manner the Earth suspended and librated in the circumference of the Grand Orbe, and situate in such sort that one of its notes, as for example, its North Pole, looketh towards such a Star or other part of the Firmament, it always keepeth directed towards the same, although carried round by the annual motion about the circumference of the said Grand Orbe. This alone is sufficient to make the Wonder cease, and to remove all difficulties. But what will *Simplificus* say, if to this non-indigence of the co-operating cause we should adde an admirable intrinsic vertue of the Terrestrial Globe, of looking with its determinate parts towards determinate parts of the Firmament, I speak of the Magnetick vertue constantly participated by any whatsoever piece of Loade-stone. And if every minute particle of that Stone have in it such a vertue, who will question but that the same more powerfully resides in this whole Terrestrial Globe, abounding in that Magnetick matter, and which happily it self, as to its internal and primary substance, is nothing else but a huge masse of Loade-stone.

An Experiment which sensibly shews that two contrary motions may naturally agree in the same moveable.

The third motion ascribed to the Earth is rather a resting immoveable.

An admirable intern vertue of the terrestrial Globe of alwayes beholding the same part of Heaven. The terrestrial Globe made of Loade-stone.

* An eminent Doctor of Physick, our Countreyman, born at Colchester, and famous for this his learned Treatise, published about 60 years since at London, *The Magnetick Philosophy of William Gilbert.*

The Pusillanimity of Popular Wits.

SIMP. Then you are one of those it seems that hold the Magnetick Philosophy *William* Gilbert.*

SALV. I am for certain, and think that all those that have seriously read his Book, and tried his experiments, will bear me company therein; nor should I despair, that what hath befallen me in this case, might possibly happen to you also, if so be a curiosity, like to mine, and a notice that infinite things in Nature are still conceal'd from the wits of mankind, by delivering you from being captivated by this or that particular writer in natural things, should but slacken the reins of your Reason, and mollifie the contumacy and tenaciousness of your sense; so as that they would not refuse to hearken sometimes to novelties never before spoken of. But (permit me to use this phrase) the pusillanimity of vulgar Wits is come to that passe, that not only like blind men, they make a gift, nay tribute of their own assent to whatsoever they find written by those Authours, which in the infancy of their Studies were laid before them, as authentick by their Tutors, but refuse to hear (not to say examine) any new Proposition or Probleme, although it not only never hath been confuted, but not so much as examined or considered by their Authours. Amongst which, one is this, of investigating what is the true, proper, primary, interne, and general matter and substance of this our Terrestrial Globe; For although it never came into the mind either of *Aristotle*, or of any one else, before *William Gilbert* to think that it might be a Magnet, so far are *Aristotle* and the rest from confusing this opinion, yet nevertheless I have met with many, that at the very first mention of it, as a Horse at his own shadow, have start back, and refused to discourse thereof, and censured the conceipt for a vain *Chymara*, yea, for a solemn madness; and its possible the Book of *Gilbert* had never come to my hands, if a Peripatetick Philosopher, of great fame, as I believe, to free his Library from its contagion, had not given it me.

SIMP. I, who ingenuously confesse my self to be one of those vulgar Wits, and never till within these few dayes that I have been admitted to a share in your conferences, could I pretend to have in the least withdrawn from those trite and popular paths, yet, for all that, I think I have advantaged my self so much, as that I could without much trouble or difficulty, master the roughnesses of these novel and fantastical opinions.

SALV. If that which *Gilbert* writeth be true, then is it no opinion, but the subject of Science; nor is it new, but as ancient as the Earth it self; nor can it (being true) be rugged or difficult, but plain and easie; and when you please I shall make you feel the same in your hand, for that you of your self fancy it to be

be a Ghost, and stand in fear of that which hath nothing in it of dreadfull, like as a little child doth fear the Hobgoblin, without knowing any more of it, save the name; as that which besides the name is nothing.

SIMP. I should be glad to be informed, and reclaimed from an error.

SALV. Answer me then to the questions that I shall ask you. And first of all, Tell me whether you believe, that this our Globe, which we inhabit and call Earth, consisteth of one sole and simple matter, or else that it is an aggregate of matters different from each other.

SIMP. I see it to be composed of substances and bodies very different; and first, for the greatest parts of the composition, I see the Water and the Earth, which extreemly differ from one another.

*The Terrestrial
Globe composed of
sundry matters.*

SALV. Let us, for this once, lay aside the Seas and other Waters, and let us consider the solid parts, and tell me, if you think them one and the same thing, or else different.

SIMP. As to appearance, I see that they are different things, there being very great heaps of unfruitful sands, and others of fruitful soiles; There are infinite sharp and sterill mountains, full of hard stones and quarries of severall kinds, as Porphyre, Alabaster, Jasper, and a thousand other kinds of Marbles: There are vast Minerals of so many kinds of metals; and in a word, such varieties of matters, that a whole day would not suffice only to enumerate them.

SALV. Now of all these different matters, do you think, that in the composition of this grand masse, there do concur portions, or else that amongst them all there is one part that far exceeds the rest, and is as it were the matter and substance of the immense lump?

SIMP. I believe that the Stones, Marbles, Metals, Gems, and the so many other severall matters are as it were Jewels, and exterior and superficial Ornaments of the primary Globe, which in grosse, as I believe, doth without compare exceed all these things put together.

SALV. And this principal and vast masse, of which those things above named are as it were excessences and ornaments, of what matter do you think that it is composed?

SIMP. I think that it is the simple, or lesse impure element of Earth.

SALV. But what do you understand by Earth? Is it haply that which is dispersed all over the fields, which is broke up with Mattocks and Ploughs, wherein we sowe corne, and plant fruits, and in which great boscaiges grow up, without the help of culture

ture, and which is, in a word, the habitation of all animals, and the womb of all vegetables?

SIMP. Tis this that I would affirm to be the substance of this our Globe.

SALV. But in this you do, in my judgment, affirm that which is not right: for this Earth which is broke up, is sowed, and is fertile, is but one part, and that very small of the surface of the Globe, which doth not go very deep, yea, its depth is very small, in comparison of the distance to the centre: and experience sheweth us, that one shall not dig very low, but one shall finde matters very different from this exterior scurf, more solid, and not good for the production of vegetables. Besides the interne parts, as being compressed by very huge weights that lie upon them, are, in all probability, slived, and made as hard as any hard rock. One may adde to this, that fecundity would be in vain conferred upon those matters which never were designed to bear fruit, but to rest eternally buried in the profound and dark abysses of the Earth.

SIMP. But who shall assure us, that the parts more inward and near to the centre are unfruitful? They also may, perhaps, have their productions of things unknown to us?

*The interne parts
of the terrestrial
Globe must of ne-
cessity be solid.
* Of MOULD.*

**Of which with
the Latin transla-
tion, I must once
more profess my
self ignorant.*

SALV. You may aswell be assured thereof, as any man else, as being very capable to comprehend, that if the integral bodies of the Universe be produced onely for the benefit of Mankind, this above all the rest ought to be destin'd to the sole conveniences of us its inhabitants. But what benefit can we draw from matters so hid and remote from us, as that we shall never be able to make use of them? Therefore the interne substance of this our Globe cannot be a matter frangible, dissippable, and non-coherent, like this superficial part which we call * EARTH: but it must, of necessity, be a most dense and solid body, and in a word, a most hard stone. And, if it ought to be so, what reason is there that should make you more scrupulous to believe that it is a Loadstone than a Porphiry, a Jasper, or other hard Marble? Happily if *Gilbert* had written, that this Globe is all compounded within of * *Pietra Serena*, or of *Chalcedon*, the paradox would have seemed to you lesse exorbitant?

SIMP. That the parts of this Globe more intern are more compressed, and so more slived together and solid, and more and more so, according as they lie lower, I do grant, and so likewise doth *Aristotle*, but that they degenerate and become other than Earth, of the same sort with this of the superficial Parts, I see nothing that oblige h me to believe.

SALV. I undertook not this discourse with an intent to prove demonstratively that the primary and real substance of this our Globe

and
this
high
d is
the
all,
nce
nde
and
erne
pon
any
in
l to
ark
ard
ps,
se,
lies
nd,
en-
om
a-
of
on-
ut
a
on
it
ar-
m-
ox
re
re
so
ne
al
ve
ur
be

Globe is Load-stone; but onely to shew that no reason could be given why one should be more unwilling to grant that it is of Load-stone, than of some other matter. And if you will but seriously consider, you shall find that it is not improbable, that one sole, pure, and arbitrary name, hath moved men to think that it consists of Earth; and that is their having made use commonly from the beginning of this word Earth, as well to signify that matter which is plowed and sowed, as to name this our Globe. The denomination of which if it had been taken from stone, as that it might as well have been taken from that as from the Earth; the saying that its primary substance was stone, would doubtlesse have found no scruple or opposition in any man. And is so much the more probable, in that I verily believe, that if one could but pare off the scurf of this great Globe, taking away but one full thousand or two thousand yards; and afterwards separate the Stones from the Earth, the accumulation of the stones would be very much bigger than that of the fertile Mould. But as for the reasons which conclusively prove *de facto*, that is our Globe is a Magnet, I have mentioned none of them, nor is this a time to alledge them, and the rather, for that to your benefit you may read them in *Gilbert*; onely to encourage you to the perusal of them, I will set before you, in a similitude of my own, the method that he observed in his Philosophy. I know you understand very well how much the knowledge of the accidents is subservient to the investigation of the substance and essence of things; therefore I desire that you would take pains to informe your self well of many accidents and properties that are found in the Magnet, and in no other stone, or body; as for instance of attracting Iron, of conferring upon it by its sole presence the same virtue, of communicating likewise to it the property of looking towards the Poles; as it also doth it self; and moreover endeavour to know by trial, that it containeth in it a virtue of conferring upon the magnetick needle not onely the direction under a Meridian towards the Poles, with an Horizontal motion, (a property a long time ago known) but a new found accident, of declining (being ballanced under the Meridian before marked upon a little spherical Magnet) of declining I say to determinate marks more or lesse, according as that needle is held nearer or farther from the Pole, till that upon the Pole it self it erecteth perpendicularly, whereas in the middle parts it is parallel to the Axis. Furthermore procure a proof to be made, whether the virtue of attracting Iron, residing much more vigorously about the Poles, than about the middle parts, this force be not notably more vigorous in one Pole than in the other, and that in all pieces of Magnet; the stronger

Our Globe would have been called stone, in stead of Earth, if that name had been given it in the beginning.

The method of Gilbert in his Philosophy.

Many properties in the Magnet.

*An Argument
proving the terre-
strial Globe to be
a Magnet.*

stronger of which Poles is that which looketh towards the South. Observe, in the next place, that in a little Magnet this South and more vigorous Pole, becometh weaker, when ever it is to take up an iron in presence of the North Pole of another much bigger Magnet: and not to make any tedious discourse of it, ascertain your self, by experience, of these and many other properties described by *Gilbert*, which are all so peculiar to the Magnet, as that none of them agree with any other matter. Tell me now, *Simplicius*, if there were laid before you a thousand pieces of several matters, but all covered and concealed in a cloth, under which it is hid, and you were required, without uncovering them, to make a guesse, by external signes, at the matter of each of them; and that in making trial, you should hit upon one that should openly shew it self to have all the properties by you already acknowledged to reside onely in the Magnet, and in no other matter, what judgment would you make of the essence of such a body? Would you say, that it might be a piece of Ebony, or Alabaſter, or Tin.

SIMP. I would say, without the least hesitation, that it was a piece of Load-stone.

SALV. If it be so, say resolutely, that under this cover and scurf of Earth, stones, metals, water, &c. there is hid a great Magnet, forasmuch as about the same there may be seen by any one that will heedfully observe the same, all those very accidents that agree with a true and visible Globe of Magnet; but if no more were to be seen than that of the Declinatory Needle, which being carried about the Earth, more and more inclineth, as it approacheth to the North Pole, and declineth lesse towards the Equinoctial, under which it finally is brought to an *Æquilibrium*, it might serve to perswade even the most scrupulous judgment. I forbear to mention that other admirable effect, which is sensibly observed in every piece of Magnet, of which, to us inhabitants of the Northern Hemisphere, the Meridional Pole of the said Magnet is more vigorous than the other; and the difference is found greater, by how much one recedeth from the Equinoctial; and under the Equinoctial both the parts are of equal strength, but notably weaker. But, in the Meridional Regions, far distant from the Equinoctial, it changeth nature, and that part which to us was more weak, acquireth more strength than the other: and all this I confer with that which we see to be done by a small piece of Magnet, in the presence of a great one, the vertue of which superating the lesser, maketh it to become obedient to it, and according as it is held, either on this or on that side the Equinoctial of the great one, maketh the self same mutations, which I have said are made by every Magnet, carried on this side

side, or that side of the Equinoctiall of the Earth.

SAGR. I was perswaded, at the very first reading of the Book of *Gilbertus*; and having met with a most excellent piece of Magnet, I, for a long time, made many Observations, and all worthy of extream wonder; but above all, that seemeth to me very stupendious of increasing the faculty of taking up Iron so much by arming it, like as the said Authour teacheth; and with arming that piece of mine, I multiplied its force in octuple proportion; and whereas unarmed it scarce took up nine ounces of Iron, it being armed did take up above six pounds: And it may be, you have seen this Loadstone in the Gallery of your Most Serene Grand Duke (to whom I presented it) upholding

The Magnet armed takes up much more Iron, than when unarmed.

+ Or Closet of rarities.

SALV. I saw it many times, and with great admiration, till that a little piece of the like stone gave me greater cause of wonder, that is, in the keeping of our Academick, which being no more than of six ounces weight, and sustaining, when unarmed, hardly two ounces, doth, when armed, take up 160 ounces, so as that it is of 80. times more force armed than unarmed, and takes up a weight 26. times greater than its own; a much greater wonder than *Gilbert* could ever meet with, who writeth, that he could never get any Loadstone that could reach to take up four times its own weight.

SAGR. In my opinion, this Stone offers to the wit of man a large Field to Philosophate in; and I have many times thought with my self, how it can be that it conferreth on that Iron, which armeth it, a strength so superiour to its own; and finally, I finde nothing that giveth me satisfaction herein; nor do I find any thing extraordinary in that which *Gilbert* writes about this particular; I know not whether the same may have befallen you.

SALV. I extreamly praise, admire, and envy this Authour, for that a conceit so stupendious should come into his minde, touching a thing handled by infinite sublime wits, and hit upon by none of them: I think him moreover worthy of extraordinary applause for the many new and true Observations that he made, to the disgrace of so many fabulous Authours, that write not only what they do not know, but what ever they hear spoken by the foolish vulgar, never seeking to assure themselves of the same by experience, perhaps, because they are unwilling to diminish the bulk of their Books. That which I could have desired in *Gilbert*, is, that he had been a little greater Mathematician, and particularly well grounded in *Geometry*, the practice whereof would have rendered him less resolute in accepting those reasons for true Demonstrations, which he produceth for true causes.

A a a

The first observers and inventors of things ought to be admired.

The true cause of the multiplication of virtue in the Magnet, by means of the arming.

Of a new effect its necessary that the cause be likewise new.

It is proved; that Iron consists of parts more subtil, pure, and compact than the magnet.

causes of the true conclusions observed by himself. Which reasons (freely speaking) do not knit and bind so fast, as those undoubtedly ought to do, in that of natural, necessary, and lasting conclusions may be alledged. And I doubt not, but that in process of time this new Science will be perfected with new observations, and, which is more, with true and necessary Demonstrations. Nor ought the glory of the first Inventor to be thereby diminished; nor do I lesse esteem, but rather more admire, the Inventor of the Harp (although it may be supposed that the Instrument at first was but rudely framed, and more rudely fingered) than an hundred other Artists, that in the ensuing Ages reduced that profession to great perfection. And methinks, that Antiquity had very good reason to enumerate the first Inventors of the Noble Arts amongst the Gods; seeing that the common wits have so little curiosity, and are so little regardful of rare and elegant things, that though they see and hear them exercitated by the exquisite professors of them, yet are they not thereby perswaded to a desire of learning them. Now judge, whether Capacities of this kind would ever have attempted to have found out the making of the Harp, or the invention of Musick upon the hint of the whistling noise of the dry sinews of a Tortois, or from the striking of four Hammers. The application to great inventions moved by small hints, and the thinking that under a primary and childish appearance admirable Arts may lie hid, is not the part of a trivial, but of a super-humane spirit. Now answering to your demands, I say, that I also have long thought upon what might possibly be the cause of this so tenacious and potent union, that we see to be made between the one Iron that armeth the Magnet, and the other that conjoyns it self unto it. And first, we are certain, that the vertue and strength of the stone doth not augment by being armed, for it neither attracts at greater distance, nor doth it hold an Iron the faster, if between it, and the arming or cap, a very fine paper, or a leaf of beaten gold, be interposed; nay, with that interposition, the naked stone takes up more Iron than the armed. There is therefore no alteration in the vertue, and yet there is an innovation in the effect. And because its necessary, that a new effect have a new cause, if it be inquired what novelty is introduced in the act of taking up with the cap or arming, there is no mutation to be discovered, but in the different contact; for whereas before Iron toucht Loadstone, now Iron toucheth Iron. Therefore it is necessary to conclude, that the diversity of contacts is the cause of the diversity of effects. And for the difference of contacts it cannot, as I see, be derived from any thing else, save from that the substance of the Iron is of parts more subtil, more pure, and more compact

ed than those of the Magnet, which are more grosse, impure, and rare. From whence it followeth, that the superficies of two Irons that are to touch, by being exquisitely plained, filed, and burnished, do so exactly conjoyn, that all the infinite points of the one meet with the infinite points of the other; so that the filaments, if I may so say, that collegate the two Irons, are many more than those that collegate the Magnet to the Iron, by reason that the substance of the Magnet is more porous, and lesse compact, which maketh that all the points and filaments of the Loadstone do not close with that which it unites unto. In the next place, that the substance of Iron (especially the well refined, as namely, the purest Steel) is of parts much more dense, subtil, and pure than the matter of the Loadstone, is seen, in that one may bring its edge to an extraordinary sharpnesse, such as is that of the Razor, which can never be in any great measure effected in a piece of Magnet. Then, as for the impurity of the Magnet, and its being mixed with other qualities of stone, it is first sensibly discovered by the colour of some little spots, for the most part white; and next by presenting a needle to it, hanging in a thread, which upon those stonyesses cannot find repose, but being attracted by the parts circumfused, seemeth to fly from *those*, and to leap upon the Magnet contiguous to *them*: and as some of those Heterogeneous parts are for their magnitude very visible, so we may believe, that there are others, in great abundance, which, for their smallnesse, are imperceptible, that are disseminated throughout the whole masse. That which I say, (namely, that the multitude of contacts that are made between Iron and Iron, is the cause of the so solid conjunction) is confirmed by an experiment, which is this, that if we present the sharpened point of a needle to the cap of a Magnet, it will stick no faster to it, than to the same stone unarmed: which can proceed from no other cause, than from the equality of the contacts that are both of one sole point. But what then? Let a Needle be taken and placed upon a Magnet, so that one of its extremities hang somewhat over, and to that present a Nail; to which the Needle will instantly cleave, insomuch that withdrawing the Nail, the Needle will stand in suspense; and with its two ends touching the Magnet and the Iron; and withdrawing the Nail yet a little further, the Needle will forsake the Magnet; provided that the eye of the Needle be towards the Nail; and the point towards the Magnet; but if the eye be towards the Loadstone, in withdrawing the Nail the Needle will cleave to the Magnet; and this, in my judgment, for no other reason, save onely that the Needle, by reason it is bigger towards the eye, toucheth in much more points than its sharp point doth.

A sensible proof of the impurity of the Magnet.

* The Author hereby meaneth that the stone doth not all consist of magnetick matter, but that the whiter specks being weak, those other parts of the Loadstone of a more dark & constant colour, contain all that vertue wherewith bodies are attracted.

* A common sewing needle.

A a a 2

S A G R.

SAGR. Your whole discourse hath been in my judgment very concluding, and this experiment of the Needle hath made me think it little inferiour to a Mathematical Demonstration; and I ingenuously confesse, that in all the Magnetick Philosophy, I never heard or read any thing, that with such strong reasons gave account of its so many admirable accidents, of which, if the causes were with the same perspicuity laid open, I know not what sweeter food our Intellects could desire.

SALV. In seeking the reasons of conclusions unknown unto us, it is requisite to have the good fortune to direct the discourse from the very beginning towards the way of truth; in which if any one walk, it will easily happen, that one shall meet with several other Propositions known to be true, either by disputes or experiments, from the certainty of which the truth of ours acquireth strength and evidence; as it did in every respect happen to me in the present Probleme, for being desirous to assure my self, by some other accident, whether the reason of the Proposition, by me found, were true; namely, whether the substance of the Magnet were really much lesse continuat than that of Iron or of Steel, I made the Artists that work in the Gallery of my Lord the Grand Duke, to smooth one side of that piece of Magnet, which formerly was yours, and then to polish and burnish it; upon which to my satisfaction I found what I desired. For I discovered many specks of colour different from the rest, but as splendid and bright, as any of the harder sort of stones; the rest of the Magnet was polite, but to the tact onely, not being in the least splendid; but rather as if it were smeared over with soot; and this was the substance of the Load-stone, and the shining part was the fragments of other stones intermixt therewith, as was sensibly made known by presenting the face thereof to filings of Iron, the which in great number leapt to the Load-stone, but not so much as one grain did stick to the said spots, which were many, some as big as the fourth part of the nail of a mans finger, others somewhat lesser, the least of all very many, and those that were scarce visible almost innumerable. So that I did assure my self, that my conjecture was true, when I first thought that the substance of the Magnet was not close and compact, but porous, or to say better, spongy; but with this difference, that whereas the sponge in its cavities and little cels containeth Air or Water, the Magnet hath its pores full of hard and heavy stone, as appears by the exquisite lustre which those specks receive. Whereupon, as I have said from the beginning, applying the surface of the Iron to the superficies of the Magnet the minute particles of the Iron, though perhaps more continuat than these of any other body (as its shining

shining more than any other matter doth shew) do not all, nay but very few of them incounter pure Magnet; and the contacts being few, the union is but weak. But because the cap of the Load-stone, besides the contact of a great part of its superficies, invests its self also with the virtue of the parts adjoyning, although they touch not; that side of it being exactly smoothed to which the other face, in like manner well polish'd of the Iron to be attracted, is apply'd, the contract is made by innumerable minute particles, if not haply by the infinite points of both the superficies, whereupon the union becometh very strong. This observation of smoothing the surfaces of the Irons that are to touch, came not into the thoughts of *Gilbert*, for he makes the Irons convex, so that their contact is very small; and thereupon it cometh to passe that the tenacity, wherewith those Irons conjoyn, is much lesser.

SAGR. I am, as I told you before, little lesse satisfied with this reason, that if it were a pure Geometrical Demonstration; and because we speak of a Physical Problem, I believe that also *Simplicius* will find himself satisfied as far as natural science admits, in which he knows that Geometrical evidence is not to be required.

SIMP. I think indeed, that *Salviatus* with a fine circumlocution hath so manifestly displayed the cause of this effect, that any indifferent wit, though not vers'd in the Sciences, may apprehend the same; but we, confining our selves to the terms of Art, reduce the cause of these and other the like natural effects to *Sympathy*, which is a certain agreement and mutual appetite which ariseth between things that are semblable to one another in qualities; as likewise on the contrary that hatred & enmity for which other things shun & abhor one another we call *Antipathy*.

SAGR. And thus with these two words men come to render reasons of a great number of accidents and effects which we see not without admiration to be produced in nature. But this kind of philosophating seems to me to have great sympathy with a certain way of Painting that a Friend of mine us'd, who writ upon the *Tele* or Canvass in chalk, here I will have the Fountain with *Diana* and her Nymphs, there certain Hariers, in this corner I will have a Huntf-man with the Head of a Stag, the rest shall be Lanes, Woods, and Hills; and lest the remainder for the Painter to set forth with Colours; and thus he perswaded himself that he had painted the Story of *Atreus*, when as he had contributed thereto nothing of his own more than the names. But whether are we wandred with so long a digression, contrary to our former resolutions? I have almost forgot what the point was that we were upon when we fell into this magnetick discourse.

Sympathy and Antipathy, terms used by Philosophers to give a reason easily of many natural effects.

A pleasant example declaring the invalidity of some Philosophical arguments.

course: and yet I had something in my mind that I intended to have spoken upon that subject.

SALV. We were about to demonstrate that third motion ascribed by *Copernicus* to the Earth to be no motion but a quiescence and maintaining of it self immutably directed with its determinate parts towards the same & determinate parts of the Universe, that is a perpetual conservation of the Axis of its diurnal revolution parallel to it self, and looking towards such and such fixed stars; which most constant position we said did naturally agree with every librated body suspended in a fluid and yielding medium, which although carried about, yet did it not change direction in respect of things external, but onely seemed to revolve in its self, in respect of that which carryed it round, and to the vessel in which it was transported. And then we added to this simple and natural accident the magnetick virtue, whereby the self Terrestrial Globe might so much the more constantly keep it immutable, —

The several natural motions of the Magnet.

SAGR. Now I remember the whole businesse; and that which then came into my minde, & which I would have intimated, was a certain consideration touching the scruple and objection of *Simplicius*, which he propounded against the mobility of the Earth, taken from the multiplicity of motions, impossible to be assigned to a simple body, of which but one sole and simple motion, according to the doctrine of *Aristotle*, can be natural; and that which I would have proposed to consideration, was the Magnet, to which we manifestly see three motions naturally to agree: one towards the centre of the Earth, as a *Grave*; the second is the circular Horizontal Motion, whereby it restores and conserves its Axis towards determinate parts of the Universe; and the third is this, newly discovered by *Gilbert*, of inclining its Axis, being in the plane of a Meridian towards the surface of the Earth, and this more and lesse, according as it shall be distant from the Equinoctial, under which it is parallel to the Axis of the Earth. Besides these three, it is not perhaps improbable, but that it may have a fourth, of revolving upon its own Axis, in case it were librated and suspended in the air or other fluid and yielding Medium, so that all external and accidental impediments were removed, and this opinion *Gilbert* himself seemeth also to applaud. So that, *Simplicius*, you see how tottering the Axiome of *Aristotle* is.

SIMP. This doth uot only not make against the Maxime, but not so much as look towards it: for that he speaketh of a simple body, and of that which may naturally consist therewith; but you propose that which befalleth a mixt body; nor do you tell us of any thing that is new to the doctrine of *Aristotle*, for that he

he likewise granteth to mixt bodies compound motions by —

SAGR. Stay a little, *Simplicius*, & answer me to the questions I shall ask you. You say that the Load-stone is no simple body, now I desire you to tell me what those simple bodies are, that mingle in composing the Load-stone.

SIMP. I know not how to tell you th'ingredients nor simples precisely, but it sufficeth that they are things elementary.

SAGR. So much sufficeth me also. And of these simple elementary bodies, what are the natural motions?

SIMP. They are the two right and simple motions, *sursum* and *deorsum*.

SAGR. Tell me in the next place. Do you believe that the motion, that shall remain natural to that same mixed body, should be one that may result from the composition of the two simple natural motions of the simple bodies compounding, or that it may be a motion impossible to be composed of them?

SIMP. I believe that it shall move with the motion resulting from the composition of the motions of the simple bodies compounding, and that with a motion impossible to be composed of these, it is impossible that it should move.

SAGR. But, *Simplicius*, with two right and simple motions, you shall never be able to compose a circular motion, such as are the two, or three circular motions that the magnet hath: you see then into what absurdities evil-grounded Principles, or, to say better, the ill-inferred consequences of good Principles carry a man; for you are now forced to say, that the Magnet is a mixture compounded of substances elementary and celestial, if you will maintain that the straight motion is a peculiar to the Elements, and the circular to the celestial bodies. Therefore if you will more safely argue, you must say, that of the integral bodies of the Universe, those that are by nature moveable, do all move circularly, and that therefore the Magnet, as a part of the true primary, and integral substance of our Globe, partaketh of the same qualities with it. And take notice of this your fallacy, in calling the Magnet a mixt body, and the Terrestrial Globe a simple body, which is sensibly perceived to be a thousand times more compound: for, besides that it containeth an hundred an hundred matters, exceeding different from one another, it containeth great abundance of this which you call mixt, I mean of the Load-stone. This seems to me just as if one should call bread a mixt body, and ** Pannada* a simple body, in which there is put no small quantity of bread, besides many other things edible. This seemeth to me a very admirable thing, amongst others of

Aristotle grants a compound motion to mixt bodies.

The motion of mixt bodies ought to be such as may result from the composition of the motions of the simple bodies compounding.

With two right motions one cannot compose circular motions.

Philosophers are forced to confesse that the Magnet is compounded of celestial substances, and of elementary.

The error of those who call the Magnet a mixt body, and the Terrestrial Globe a simple body.

* *Ogliopotrída* a Spanish dish of many ingredients bould together.

*The Discourses
of Peripateticks,
full of errors and
contradictions.*

of the Peripateticks, who grant (not can it be denied), that our Terrestrial Globe is, *de facto*, a compound of infinite different matters; and grant farther that of compound bodies the motion ought to be compound: now the motions that admit of composition are the right and circular. For the two right motions, as being contrary, are incompatible together; they affirm, that the pure Element of Earth is no where to be found; they confesse, that it never hath been moved with a local motion; and yet they will introduce in Nature that body which is not to be found, and make it move with that motion which it never exercised, nor never shall do, and to that body which hath, and ever had a being, they deny that motion, which before they granted, ought naturally to agree therewith.

SALV. I beseech you, *Sagredus*, let us not weary our selves any more about these particulars, and the rather, because you know that our purpose was not to determine resolutely, or to accept for true, this or that opinion, but only to propose for our divertisement such reasons, and answers as may be alledged on the one side, or on the other; and *Simplicius* maketh this answer, in defence of his Peripateticks, therefore let us leave the judgment in suspense, and remit the determination into the hands of such as are more known than we. And because I think that we have, with sufficient prolixity, in these three dayes, discoursed upon the Systeme of the Universe, it will now be seasonable, that we proceed to the grand accident, from whence our Disputations took beginning, I mean, of the ebbing and flowing of the Sea, the cause whereof may, in all probability, be referred to the motion of the Earth. But that, if you so please, we will reserve till to morrow. In the mean time, that I may not forget it, I will speak to one particular, to which I could have wished, that *Gilbert* had not lent an ear; I mean that of admitting, that in case a little Sphere of Loadstone might be exactly librated, it would revolve in it self; because there is no reason why it should do so. For if the whole Terrestrial Globe hath a natural faculty of revolving about its own centre in twenty four hours, and that all its parts ought to have the same, I mean, that faculty of turning round together with their *whole*, about its centre in twenty four hours; they already have the same in effect, whilst that, being upon the Earth, they turn round along with it: And the assigning them a revolution about their particular centres, would be to ascribe unto them a second motion much different from the first: for so they would have two, namely, the revolving in twenty four hours about the centre of their *whole*; and the turning about their own: now this second is arbitrary, nor is there any

*An improbable
effect admired
by Gilbertus in the
Loadstone.*

reason for the introducing of it : If by plucking away a piece of Loadstone from the whole natural masse, it were deprived of the faculty of following it, as it did, whilst it was united thereto, so that it is thereby deprived of the revolution about the universal centre of the Terrestrial Globe, it might haply, with somewhat greater probability be thought by some, that the said Magnet was to appropriate to it self a new conversion about its particular centre ; but if it do no lesse, when separated, than when conjoynd, continue always to pursue its first, eternal, and natural course, to what purpose should we go about to obtrude upon it another new one ?

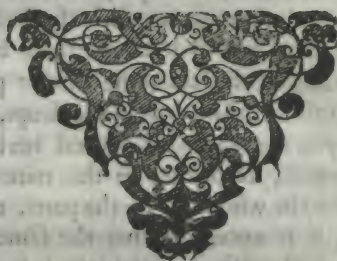
S A G R. I understand you very well, and this puts me in mind of a Discourse very like to this for the vanity of it, falling from certain Writers upon the Sphere, and I think, if I well remember, amongst others from *Sacrobosco*, who, to shew how the Element of Water, doth, together with the Earth, make a compleat Spherical Figure, and so between them both compose this our Globe, writeth, that the seeing the small particles of water shape themselves into rotundity, as in the drops, and in the dew daily apparent upon the leaves of several herbs, is a strong argument ; and because, according to the trite Axiome, there is the same reason for the whole, as for the parts, the parts affecting that same figure, it is necessary that the same is proper to the whole Element : and truth is, methinks it is a great oversight that these men should not perceive so apparent a vanity, and consider that if their argument had run right, it would have followed, that not only the small drops, but that any whatsoever greater quantity of water separated from the whole Element, should be reduced into a Globe: Which is not seen to happen; though indeed the Senses may see, and the Understanding perceive that the Element of Water loving to form it self into a Spherical Figure about the common centre of gravity, to which all grave bodies tend (that is, the centre of the Terrestrial Globe) it therein is followed by all its parts, according to the Axiome ; so that all the surfaces of Seas, Lakes, Pools, and in a word, of all the parts of Waters contained in vessels, distend themselves into a Spherical Figure, but that Figure is an arch of that Sphere that hath for its centre the centre of the Terrestrial Globe ; and do not make particular Spheres of themselves.

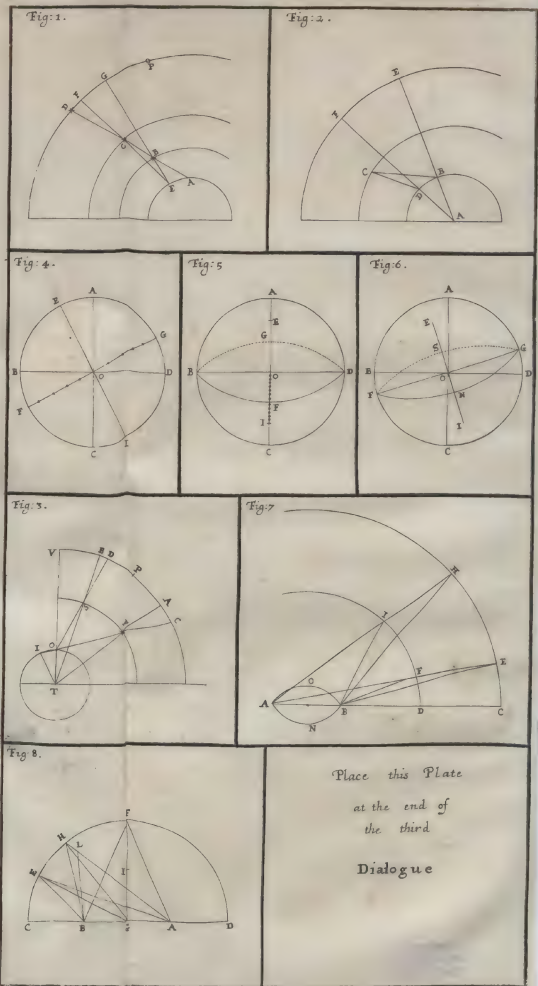
S A L V. The errour indeed is childish ; and if it had been onely the single mistake of *Sacrobosco*, I would easily have allowed him in it ; but to pardon it also to his Commentators, and to other famous men, and even to *Ptolomy*

B b b

The vain argumentation of some to prove the Element of Water to be of a Spherical superficies.

himselfe; this I cannot do, without blushing for their reputation. But it is high time to take leave, it now being very late, and we being to meet again to morrow, at the usual hour, to bring all the foregoing Discourses to a final conclusion.





BIBLIOTHECA
UNIVERSITATIS
HAUNIENSIS

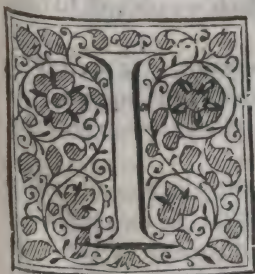
GALILÆUS
 Gailæus Lyncæus,
 HIS
 SYSTE^ME
 OF THE
 WORLD.

The Fourth Dialogue.

INTERLOCUTORS.

SALVIATUS, SAGREDUS, & SIMPLICIUS.

SAGR.



know not whether your return to our accustomed conferences hath really been later than usual, or whether the desire of hearing the thoughts of *Salviatus*, touching a matter so curious, hath made me think it so: But I have tarried a long hour at this window, expecting every moment when the *Gondola* would appear that I sent to fetch you.

SALV. I verily believe that your imagination more than our tarriance hath prolonged the time: and to make no longer demurre, it would be well, if without interposing more words, we came to the matter it self; and did shew, that nature hath permitted (whether the business *in rei veritate* be so, or else to play

B b b 2

*Nature in sport
 maketh the ebbing
 and flowing of the
 Sea, to approve the
 Earths mobility.*

The tide, and mobility of the Earth mutually confirm each other

All terrene effects, indifferently confirm the motion or rest of the Earth, except the ebbing and flowing of the Sea.

The first general conclusion of the impossibility of the ebbing and flowing the immobility of the terrestrial Globe being granted.

The knowledge of the effects contributes to the investigation of the causes.

and sport with our Fancies) hath, I say, hath permitted that the motions for every other respect, except to resolve the ebbing and flowing of the Sea, assigned long since to the earth, should be found now at last to answer exactly to the cause thereof; and, as it were, with mutual emulation; the said ebbing and flowing to appear in confirmation of the Terrestrial motion: the *judices* whereof have hitherto been taken from the celestial Phenomena, in regard that of those things that happen on Earth, not any one was of force to prove one opinion more than another, as we already have at large proved, by shewing that all the terrene occurrences upon which the stability of the Earth and mobility of the Sun and Firmament is commonly inferred, are to seem to us performed in the same manner, though we supposed the mobility of the Earth, and the immobility of them. The Element of Water only, as being most vast, and which is not annexed and concatenated to the Terrestrial Globe as all its other solid parts are; yea, rather which by reason of its fluidity remaineth apart *sui juris*, and free, is to be ranked amongst those sublunary things, from which we may collect some hinte and intimation of what the Earth doth in relation to motion and rest. After I had many and many a time examined with my self the effects and accidents, partly seen and partly understood from others, that are to be observed in the motions of waters: and moreover read and heard the great vanities produced by many, as the causes of those accidents, I have been induced upon no slight reasons to omit these two conclusions (having made withal the necessary presuppositions) that in case the terrestrial Globe be immoveable, the flux and reflux of the Sea cannot be natural; and that, in case those motions be conferred upon the said Globe, which have been long since assigned to it, it is necessary that the Sea be subject to ebbing and flowing, according to all that which we observe to happen in the same.

SAG. The Proposition is very considerable, as well for it self, as for what followeth upon the same by way of consequence, so that I shall the more intently hearken to the explanation and confirmation of it.

SALV. Because in natural questions, of which number this which we have in hand is one, the knowledge of the effects is a means to guide us to the investigation and discovery of the causes, and without which we should walk in the dark, nay with more uncertainty, for that we know not whither we would go, whereas the blind, at least, know where they desire to arrive; therefore first of all it is necessary to know the effects whereof we enquire the causes: of which effects you, *Sagredus*, ought more abundantly and more certainly to be informed than I am,

as

as one, that besides your being born, and having, for a long time, dwelt in *Venice*, where the Tides are very notable for their greatnesse, have also sailed into *Syria*, and, as an ingenuous and apprehensive wit, must needs have made many Observations upon this subject: whereas I, that could onely for a time, and that very short, observe what happened in these extreame parts of the *Adriatick* Gulph, and in our Seas below about the *Tyrrhene* shores, must needs take many things upon the relation of others, who, for the most part, not very well agreeing, and consequently being very uncertain, contribute more of confusion than confirmation to our speculations. Neverthelessse, from those that we are sure of, and which are the principal, I think I am able to attain to the true and primary causes; not that I pretend to be able to produce all the proper and adequate reasons of those effects that are new unto me, and which consequently I could never have thought upon. And that which I have to say, I propose only, as a key that openeth the doore to a path never yet trodden by any, in certain hope, that some wits more speculative than mine, will make a further progresse herin, and penetrate much farther than I shall have done in this my first Discovery: And although that in other Seas, remote from us, there may happen several accidents, which do not happen in our *Mediterranean* Sea, yet doth not this invalidate the reason and cause that I shall produce, if so be that it verifie and fully resolve the accidents which evene in our Sea: for that in conclusion there can be but one true and primary cause of the effects that are of the same kind. I will relate unto you, therefore, the effects that I know to be true, and assigne the causes thereof that I think to be true, and you also, Gentlemen, shall produce such others as are known to you, besides mine, and then we will try whether the cause, by me alledged, may satisfie them also.

I therefore affirm the periods that are observed in the fluxes and refluxes of the Sea-waters to be three: the first and principal is this great and most obvious one; namely, the diurnal, according to which the intervals of some hours with the waters flow and ebbe; and these intervals are, for the most part, in the *Mediterranean* from six hours to six hours, or thereabouts, that is, they for six hours flow, and for six hours ebbe. The second period is monethly, and it seemes to take its origen from the motion of the Moon, not that it introduceth other motions, but only altereth the greatnesse of those before mentioned, with a notable difference, according as it shall wax or wane, or come to the Quadrature with the Sun. The third Period is annual, and is seen to depend on the Sunne, and onely altereth the diurnal motions,

Three Periods
of ebbings and
flowings; diurnal,
monethly, and annual.

*Varieties that
happen in the diurnal
period.*

* A Strait, so
called.

* Or Ilva.

* Or, Creta.

*The cause of the
ebbing and flowing
alleged by a cer-
tain modern Phi-
losopher.*

motions, by making them different in the times of the Solstices, as to greatnesse, from what they are in the Equinoxes.

We will speak (in the first place, of the diurnal motion, as being the principal, and upon which the Moon and Sun seem to exercise their power secondarily, in their monethly and annual alterations. Three differences are observable in these horary mutations; for in some places the waters rise and fall, without making any progressive motion; in others, without rising or falling they run one while towards the East, and recur another while towards the West; and in others they vary the heights and course also, as happeneth here in *Venice*, where the Tides in coming in rise, and in going out fall; and this they do in the extremities of the lengths of Gulphs that distend from West to East, and terminate in open shores, up along which shores the Tide at time of flood hath room to extend it self: but if the course of the Tide were intercepted by Clifffes and Banks of great height and steepnesse, there it will flow and ebbe without any progressive motion. Again, it runs to and again, without changing height in the middle parts of the Mediterrane, as notably happeneth in the * *Faro de Messina*, between *Seylla* and *Carybdia*, where the Currents, by reason of the narrownesse of the Channel, are very swift; but in the more open Seas, and about the Isles that stand farther into the Mediterranean Sea, as the *Baleares*, *Corfica*, *Sardignia*, * *Elba*, *Sicily* towards the *African* Coasts, *Malta*, * *Candia*, &c. the changes of watermark are very small; but the currents indeed are very notable, and especially when the Sea is pent between Islands, or between them and the Continent.

Now these onely true and certain effects, were there no more to be observed, do, in my judgment, very probably perswade any man, that will contain himself within the bounds of natural causes, to grant the mobility of the Earth: for to make the vessel (as it may be called) of the Mediterrane stand still, and to make the water contained therein to do, as it doth, exceeds my imagination, and perhaps every mans else, who will but pierce beyond the rinde in these kind of inquiries.

SIMPLE. These accidents, *Salviatus*, begin not now, they are most ancient; and have been observed by very many, and severall have attempted to assigne, some one, some another, cause for the same: and there dwelleth not many miles from hence a famous Peripatetick, that alledgeth a cause for the same newly fished out of a certain Text of *Aristotle*, not well understood by his Expositors, from which Text he collecteth, that the true cause of these motions doth only proceed from the different profundities of Seas: for that the waters of greatest depth being greater in abun-

abundance, and therefore more grave, drive back the Waters of lesse depth, which being afterwards raised, desire to descend, and from this continual colluctation or contest proceeds the ebbing and flowing. Again those that referre the same to the Moon are many, saying that she hath particular Dominion over the Water; and at last a certain Prelate hath published a little Treatise, wherein he saith that the Moon wandering too and fro in the Heavens attracteth and draweth towards it a Masse of Water, which goeth continually following it, so that it is full Sea alwayes in that part which lyeth under the Moon; and because, that though she be under the Horizon, yet neverthelesse the Tide returneth, he saith that no more can be said for the salving of that particular, save onely, that the Moon doth not onely naturally retain this faculty in her self; but in this case hath power to confer it upon that degree of the Zodiack that is opposite unto it. Others, as I believe you know, do say that the Moon is able with her temperate heat to rarefie the Water, which being rarefied, doth thereupon flow. Nor hath there been wanting some that

The cause of the ebbing and flowing ascribed to the Moon by a certain Prelate.

Hieronymus Borrius and other Peripateticks refer it to the temperate heat of the Moon.

SAGR. I pray you *Simplicius* let us hear no more of them, for I do not think it is worth the while to waste time in relating them, or to spend our breath in confuting them; and for your part, if you gave your assent to any of these or the like fooleries, you did a great injury to your judgment; which neverthelesse I acknowledge to be very piercing.

SALV. But I that am a little more flegmatick than you, *Sagredus*, will spend a few words in favour of *Simplicius*, if haply he thinks that any probability is to be found in those things that he hath related. I say therefore The Waters, *Simplicius*, that have their exterior superficies higher, repel those that are inferior to them, and lower; but so do not those Waters that are of greatest profundity; and the higher having once driven back the lower, they in a short time grow quiet and level. This your *Peripatetick* must needs be of an opinion, that all the Lakes in the World that are in a calme, and that all the Seas where the ebbing and flowing is insensible, are level in their bottoms; but I was so simple, that I perswaded my self that had we no other plummet to sound with, the Isles that advance so high above Water, had been a sufficient evidence of the unevennesse of their bottoms. To that Prelate I could say that the Moon runneth every day along the whole Mediterrane, and yet its Waters do not rise thereupon, save onely in the very extreame bounds of it Eastward, and here to us at *Venice*. And for those that make the Moons temperate heat able to make the Water swell, bid them put fire under a Kettle full of Water, and hold their

Answers to the vanities alledged as causes of the ebbing and flowing.

+ Or rather smooth.

The Isles are tokens of the unevennesse of the bottoms of Seas.

Poetick wits of
two kinds.

True hath not
so little light as
not to be discover-
ed amidst the um-
brages of fal-
shoods.

Aristotle holdeth
these effects to be
miraculous, of
which the causes
are unknown.

their right hand therein till that the Water by reason of the heat do rise but one sole inch, and then let them take it out, and write off the tumefaction of the Sea. Or at least desire them to shew you how the Moon doth to rarefie a certain part of the Waters, and not the remainder; as for instance, these here of *Venice*, and not those of *Ancona*, *Naples*, *Genova*; the truth is Poetick Wits are of two kinds, some are ready and apt to invent Fables, and others disposed and inclined to believe them.

SIMP. I believe that no man believeth Fables, so long as he knows them to be so; and of the opinions concerning the causes of ebbing and flowing, which are many, because I know that of one single effect there is but one single cause that is true and primary, I understand very well, and am certain that but one alone at the most can be true, and for all the rest I am sure that they are fabulous, and false; and its possible that the true one may not be among those that have been hitherto produced; nay I verily believe that it is not; for it would be very strange that the truth should have so little light, as that it should not be visible amongst the umbrages of so many falshoods. But this I shall say with the liberty that is permitted amongst us, that the introduction of the Earths motion, and the making it the cause of the ebbing and flowing of Tides, seemeth to me as yet a conjecture no lesse fabulous than the rest of those that I have heard; and if there should not be proposed to me reasons more conformable to natural matters, I would without any more ado proceed to believe this to be a supernatural effect, and therefore miraculous, and unsearchable to the understandings of men, as infinite others there are, that immediately depend on the Omnipotent hand of God.

SAGR. You argue very prudently, and according to the Doctrine of Aristotle, who you know in the beginning of his mechanical questions referreth those things to a Miracle, the causes whereof are occult. But that the cause of the ebbing and flowing is one of those that are not to be found out, I believe you have no greater proof than onely that you see, that amongst all those that have hitherto been produced for true causes thereof, there is not one wherewith, working by what artifice you will, we are able to represent such an effect; in regard that neither with the light of the Moon nor of the Sun, nor with temperate heats, nor with different profundities, shall one ever artificially make the Water contained in an immoveable Vessel to run one way or another, and to ebbe and flow in one place, and not in another. But if without any other artifice, but with the onely moving of the Vessel, I am able punctually to represent all those mutations that are observed in the Sea Water, why will you refuse this reason and run to a Miracle?

SIMP.

SIMP. I will run to a Miracle still, if you do not with some other natural causes, besides that of the motion of the Vessels of the Sea-water disswade me from it; for I know that those Vessels move not, in regard that all the entire Terrestrial Globe is naturally immoveable.

SALV. But do not you think, that the Terrestrial Globe might supernaturally, that is, by the absolute power of God, be made moveable? SIMP. Who doubts it?

SALV. Then *Simplicius*, seeing that to make the flux and reflux of the Sea, it is necessary to introduce a Miracle, let us suppose the Earth to move miraculously, upon the motion of which the Sea moveth naturally: and this effect shall be also the more simple, and I may say natural, amongst the miraculous operations, in that the making a Globe to move round, of which kind we see many others to move, is lesse difficult than to make an immense masse of water go forwards and backwards, in one place more swiftly, and in another lesse; and to rise and fall in some places more; in some lesse, and in some not at all: and to work all these different effects in one and the same Vessel that containeth it: besides, that these are several Miracles, and that is but one onely. And here it may be added, that the Miracle of making the water to move is accompanied with another, namely, the holding of the Earth stedfast against impetuosities of the water, able to make it swage sometimes one way, and sometimes another, if it were not miraculously kept to rights.

SAGR. Good *Simplicius*, let us for the present suspend our judgement about sentencing the new opinion to be vain that *Salviatus* is about to explicate unto us, nor let us so hastily flye out into passion like the scolding overgrown Haggs: and as for the Miracle, we may as well recurre to it when we have done hearing the Discourses contained within the bounds of natural causes: though to speak freely, all the Works of nature, or rather of God, are in my judgement miraculous.

SALV. And I am of the same opinion; nor doth my saying, that the motion of the Earth is the Natural cause of the ebbing and flowing, hinder, but that the said motion of the Earth may be miraculous. Now reassuming our Argument, I apply, and once again affirm, that it hath been hitherto unknown how it might be that the Waters contained in our Mediterranean Straights should make those motions; as we see it doth, if so be the said Straight, or containing Vessel were immoveable. And that which makes the difficulty, and rendreth this matter inextricable, are the things which I am about to speak of, and which are daily observed. Therefore lend me your attention.

We are here in *Venice*, where at this time the Waters are low,

¶ ¶

the

*It is proved
impossible that
there should natu-
rally be any ebbing
and flowing, the
Earth being im-
moveable.*

* Palms.

+ *Lio* is a fair
Port in the Vene-
tian Gulph, lying
N. E. from the
City.

the Sea calm, the Air tranquil; suppose it to be young flood, and that in the term of five or six hours the water do rise ten * hand breadths and more; that rise is not made by the first water, which was said to be rarefied, but it is done by the accession of new Water: Water of the same sort with the former, of the same brackishness, of the same density, of the same weight: Ships, *Simplicius*, float therein as in the former, without drawing an hairs breadth more water; a Barrel of this second doth not weigh one single grain more or less than such another quantity of the other, and retaineth the same coldness without the least alteration: And it is, in a word, Water newly and visibly entred by the Channels and Mouth of the * *Lio*. Consider now, how and from whence it came thither. Are there happily hereabouts any Gulphs or Whirle pools in the bottom of the Sea, by which the Earth drinketh in and spueth out the Water, breathing as it were a great and monstrous Whale? But if this be so, how comes it that the Water doth not flow in the space of six hours in *Ancona*, in * *Ragusa*, in *Corfu*, where the Tide is very small, and happily unobservable? Who will invent a way to pour new Water into an immoveable Vessel, and to make that it rise only in one determinate part of it, and in other places not? Will you say, that this new Water is borrowed from the Ocean, being brought in by the Straight of *Gibraltar*? This will not remove the doubt aforesaid, but will beget a greater. And first tell me what ought to be the current of that Water, that entering at the Straights mouth, is carried in six hours to the remotest Creeks of the Mediterrane, at a distance of two or three thousand Miles, and that returneth the same space again in a like time at its going back? What would Ships do that lye out at Sea? What would become of those that should be in the Straights-mouth in a continual precipice of a vast accumulation of Waters, that entering in at a Channel but eight Miles broad, is to give admittance to so much Water as in six hours overfloweth a tract of many hundred Miles broad, & thousands in length? What Tygre, what Falcon runneth or flyeth with so much swiftness? With the swiftness, I say, of above 400 Miles an hour. The currents run (nor can it be denied) the long-wayes of the Gulph, but so slowly, as that a Boat with Oars will out-go them, though indeed not without defalking for their wanderings. Moreover, if this Water come in at the Straight, the other doubt yet remaineth, namely, how it cometh to flow here so high in a place so remote, without first rising a like or greater height in the parts more adjacent? In a word, I cannot think that either obstinacy, or sharpness of wit can ever find an answer to these Objections, nor consequently to maintain the stability of the Earth against them, keeping within the bounds of Nature.

S A G R.

SAGR. I have all the while perfectly apprehended you in this; and I stand greedily attending to hear in what manner these wonders may occur without obstruction from the motion already assigned to the Earth.

SALV. These effects being to ensue in consequence of the motions that naturally agree with the Earth, it is necessary that they not onely meet with no impediment or obstacle, but that they do follow easily, & not onely that they follow with facility, but with necessity, so as that it is impossible that it should succeed otherwise; for such is the property & condition of things natural & true. Having therefore shewen the impossibility of rendring a reason of the motions discerned in the Waters, & at the same time to maintain the immobility of the vessel that containeth them: we may proceed to enquire, whether the mobility of the Container may produce the required effect, in the manner that it is observed to evene.

Two kinds of motions may be conferred upon a Vessel, whereby the Water therein contained, may acquire a faculty of fluctuating in it, one while towards one side; and another while towards another; and there one while to ebbe, and another while to flow. The first is, when first one, and then another of those sides is declined, for then the Water running towards the inclining side, will alternately be higher and lower, sometimes on one side, and sometimes on another. But because that this rising and abating is no other than a recession and accession to the centre of the Earth, such a motion cannot be ascribed to the concavities of the said Earth, that are the Vessels which contain the Waters; the parts of which Vessel cannot by any whatsoever motion assigned to the Earth, be made to approach or recede from the centre of the same. The other sort of motion is, when the Vessel moveth (without inclining in the least) with a progressive motion, not uniform, but that changeth velocity, by sometimes accelerating, and other times retarding: from which disparity it would follow, that the Water contained in the Vessel its true, but not fixed fast to it, as its other solid parts, but by reason of its fluidity, as if it were separated and at liberty, and not obliged to follow all the mutations of its Container, in the retardation of the Vessel, it keeping part of the *impetus* before conceived, would run towards the the preceding part, whereupon it would of necessity come to rise; and on the contrary, if new velocity should be added to the Vessel, with retaining parts of its tardity, staying somewhat behind, before it could habituate it self to the new *impetus*, it would hang back towards the following part, where it would come to rise something. The which effects we may plainly declare and make out to the Sense by the example of one of those same Barks yonder,

True and natural effects follow without difficulty.

Two sorts of motions of the containing Vessel, may make the contained water to rise and fall.

The Cavities of the Earth cannot approach or go farther from the centre of the same.

The progressive and uneven motion may make the water contained in a Vessel to run to and fro.

Ccc 2

* Lizzad

† A Town lying S.E. of Venice

* *Lizza Fusina*, laden with fresh water, for the service of the City. Let us therefore fancy one of those Barks, to come from thence with moderate velocity along the Lake, carrying the water gently, of which it is full: and then either by running a ground, or by some other impediment that it shall meet with, let it be notably retarded. The water therein contained shall not, by that means, lose, as the Bark doth, its pre-conceived *impetus*, but retaining the same, shall run forwards towards the prow, where it shall rise notably, falling as much a stern. But if, on the contrary, the said Bark, in the midst of its smooth course, shall have a new velocity, with notable augmentation added to it, the water contained before it can habituate it self thereto, continuing in its tardity, shall stay behinde; namely a stern, where of consequence it shall mount, and abate for the same at the prow. This effect is undoubted and manifest, and may hourly be experimented; in which I desire that for the present three particulars may be noted. The first is, that to make the water to rise on one side of the vessel, there is no need of new water, nor that it run thither, forsaking the other side. The second is, that the water in the middle doth not rise or fall notably, unless the course of the Bark were not before that very swift, and the shock or other arrest that held it exceeding strong and sudden, in which case it is possible, that not only all the water might run forwards, but that the greater part thereof might issue forth of the Bark: and the same also would ensue, whilst that being under sail in a smooth course, a most violent *impetus* should, upon an instant, overtake it: But when to its calme motion there is added a moderate retardation or incitation, the middle parts (as I said) unobservedly rise and fall: and the other parts, according as they are neerer to the middle, rise the lesse; and the more remote, more. The third is, that whereas the parts about the midst do make little alteration in rising and falling, in respect of the waters of the sides; on the contrary, they run forwards and backwards very much, in comparison of the extreame. Now, my Masters, that which the Bark doth, in respect of the water by it contained, and that which the water contained doth, in respect of the Bark its container, is the self same, to an hair, with that which the Mediterranean Vessel doth, in respect of the waters in it contained, and that which the waters contained do, in respect of the Mediterranean Vessel their container. It followeth now that we demonstrate how, and in what manner it is true, that the Mediterrane, and all the other Straits; and in a word, all the parts of the Earth do all move, with a motion notably uneven, though no motion that is not regular and uniform, is thereby assigned to all the said Globe taken collectively.

The parts of the terrestrial Globe accelerate and retard in their motion.

SIMP.

SIMP. This Proposition, at first sight to me, that am neither Geometrician nor Astronomer, hath the appearance of a very great Paradox; and if it should be true, that the motion of the whole, being regular, that of the parts, which are all united to their whole, may be irregular, the Paradox will overthrow the Axiome that affirmeth, *Eandem esse rationem totius & partium*.

SALV. I will demonstrate my Paradox, and leave it to your care, *Simplicius*, to defend the Axiome from it, or else to reconcile them; and my demonstration shall be short and familiar, depending on the things largely handled in our precedent conferences, without introducing the least syllable, in favour of the flux and reflux.

We have said, that the motions assigned to the Terrestrial Globe are two, the first Annual, made by its centre about the circumference of the Grand Orb, under the Ecliptick, according to the order of the Signes, that is, from West to East; the other made by the said Globe revolving about its own centre in twenty four hours; and this likewise from West to East: though about an Axis somewhat inclined, and not equidistant from that of the Annual conversion. From the mixture of these two motions, each of it self uniform, I lay, that there doth result an uneven and deformed motion in the parts of the Earth. Which, that it may the more easily be understood, I will explain, by drawing a Scheme thereof. And first, about the centre A [in Fig. 1. of this Dialogue] I will describe the circumference of the Grand Orb BC, in which any point being taken, as B, about it as a centre we will describe this lesser circle DEFG, representing the Terrestrial Globe; the which we will suppose to run thorow the whole circumference of the Grand Orb, with its centre B, from the West towards the East, that is, from the part B towards C; and moreover we will suppose the Terrestrial Globe to turn about its own centre B likewise from West to East; that is, according to the succession of the points DEFG, in the space of twenty four hours. But here we ought carefully to note, that a circle turning round upon its own centre, each part of it must, at different times, move with contrary motions: the which is manifest, considering that whilst the parts of the circumference, about the point D move to the left hand, that is, towards E, the opposite parts that are about F, approach to the right hand, that is, towards G; so that when the parts D shall be in F, their motion shall be contrary to what it was before, when it was in D. Furthermore, the same time that the parts E descend, if I may so speak, towards F, those in G ascend towards D. It being therefore presupposed, that there

*Demonstrations
how the parts of
the terrestriall
Globe accelerate
and retard.*

*The parts of a
Circle regularly
moved about its
own centre move in
divers times with
contrary motions.*

The mixture of the two motions annual and diurnal, causeth the inequality in the motion of the parts of the terrestrial Globe.

there are such contrarieties of motions in the parts of the Terrestrial Surface, whilst it turneth round upon its own centre, it is necessary, that in conjoyning this Diurnal Motion, with the other Annual, there do result an absolute motion for the parts of the said Terrestrial Superficies, one while very accelerate, and another while as slow again. The which is manifest, considering first the parts about D, the absolute motion of which shall be extream swift, as that which proceedeth from two motions made both one way, namely, towards the left hand; the first of which is part of the Annual Motion, common to all the parts of the Globe, the other is that of the said point D, carried likewise to the left, by the Diurnal Revolution; so that, in this case, the Diurnal motion increaseth and accelerateth the Annual. The contrary to which happeneth in the opposite part F, which, whilst it is by the common annual motion carried, together with the whole Globe, towards the left, it happeneth to be carried by the Diurnal conversion also towards the right: so that the Diurnal motion by that means detracteth from the Annual, whereupon the absolute motion, resulting from the composition of both the other, is much retarded. Again, about the points E and G, the absolute motion becometh in a manner equal to the simple Annual one, in regard that little or nothing increaseth or diminisheth it, as not tending either to the left hand, or to the right, but downwards and upwards. We will conclude therefore, that like as it is true, that the motion of the whole Globe, and of each of its parts, would be equal and uniforme, in case they did move with one single motion, whether it were the meer Annual, or the single Diurnal Revolution, so it is requisite, that mixing those two motions together, there do result thence for the parts of the said Globe irregular motions, one while accelerated, and another while retarded, by means of the additions or subtractions of the Diurnal conversion from the annual circulation. So that, if it be true (and most true it is, as experience proves) that the acceleration and retardation of the motion of the Vessel, makes water contained therein to run to and again the long wayes of it, and to rise and fall in its extreames, who will make scruple of granting, that the said effect may, nay ought to succeed in the Sea-waters, contained within their Vessels, subject to such like alterations, and especially in those that distend themselves long-wayes from West to East, which is the course that the motion of those same Vessels steereth? Now this is the most potent and primary cause of the ebbing and flowing, without the which no such effect would ensue. But because the particular accidents are many and various, that in several places and times are observed, which must of necessity have dependance on

The most potent and primary cause of the ebbing and flowing.

on other different concomitant causes, although they ought all to have connexion with the primary; therefore it is convenient that we propound and examine the several accidents that may be the causes of such different effects.

The first of which is, that when ever the water, by means of a notable retardation or acceleration of the motion of the Vessel, its container, shall have acquired a cause of running towards this or that extrem; and shall be raised in the one, and abated in the other, it shall not nevertheless continue, for any time in that state, when once the primary cause is ceased: but by vertue of its own gravity and natural inclination to level and grow, even it shall speedily return backwards of its own accord, and, as being grave and fluid, shall not only move towards *Æquilibrium*; but being impelled by its own *impetus*, shall go beyond it, rising in the part, where before it was lowest; nor shall it stay here, but returning backwards anew, with more reiterated reciprocations of its undulations, it shall give us to know, that it will not from a velocity of motion, once conceived, reduce it self, in an instant, to the privation thereof, and to the state of rest, but will successively, by decreasing a little and a little, reduce it self unto the same, just in the same manner as we see a weight hanging at a cord, after it hath been once removed from its state of rest, that is, from its perpendicularity, of its own accord, to return thither and settle it self, but not till such time as it shall have often past to one side, and to the other, with its reciprocall vibrations.

The second accident to be observed is, that the before-declared reciprocations of motion come to be made and repeated with greater or lesser frequency, that is, under shorter or longer times, according to the different lengths of the Vessels containing the waters; so that in the shorter spaces the reciprocations are more frequent, and in the longer more rare: just as in the former example of pendent bodies, the vibrations of those that are hanged to longer cords are seen to be lesse frequent, than those of them that hang at shorter strings.

And here, for a third observation, it is to be noted, that not onely the greater or lesser length of the Vessel is a cause that the water maketh its reciprocations under different times; but the greater or lesser profundity worketh the same effect. And it happeneth, that of waters contained in receptacles of equall length, but of unequal depth, that which shall be the deepest, maketh its undulations under shorter times; and the reciprocations of the shallower waters are lesse frequent.

Fourthly, there are two effects worthy to be noted, and diligently observed, which the water worketh in those its vibrations;

Sundry accidents that happen in the ebbings & flowings. The first accident.

*The Water raised in one end of the Vessel returns to its first *Æquilibrium*.*

In the shorter Vessels the undulations of waters are more frequent.

The greater profundity maketh the undulations of waters more frequent.

Water riseth & falleth in the extreame parts of the Vessel, and runneth to and fro in the midst.

An accident of the Earths motions impossible to be reduced to practice by art.

tions; the one is its rising and falling alternately towards the one and other extremity; the other is its moving and running, to so speak, Horizontally forwards and backwards. Which two different motions differently reside in divers parts of the Water: for its extreame parts are those which most eminently rise and fall; those in the middle never absolutely moving upwards and downwards; of the rest successively those that are nearest to the extreames rise and fall proportionally more than the remote: but on the contrary, touching the other progressive motion forwards and backwards, the middle parts move notably, going and returning, and the waters that are in the extreame parts gain no ground at all; save onely in case that in their rising they overflow their banks, and break forth of their first channel and receptacle; but where there is the obstacle of banks to keep them in, they onely rise and fall; which yet hindereth not the waters in the middle from fluctuating to and again; which likewise the other parts do in proportion, undulating more or lesse, according as they are neerer or more remote from the middle.

The fifth particular accident ought the more attentively to be considered, in that it is impossible to represent the effect thereof by an experiment or example; and the accident is this. In the vessels by us framed with art, and moved, as the above-named Bark, one while more, and another while lesse swiftly, the acceleration and retardation is imparted in the same manner to all the vessel, and to every part of it; so that whilst *v. g.* the Bark forbearth to move, the parts precedent retard no more than the subsequent, but all equally partake of the same retardment; and the self-same holds true of the acceleration, namely, that conferring on the Bark a new cause of greater velocity, the Prow and Poop both accelerate in one and the same manner. But in huge great vessels, such as are the very long bottomes of Seas, albeit they also are no other than certain cavities made in the solidity of the Terrestrial Globe, it alwayes admirably happeneth, that their extreames do not unitedly equall, and at the same moments of time increase and diminish their motion, but it happeneth that when one of its extreames hath, by vertue of the commixtion of the two Motions, Diurnal, and Annual, greatly retarded its velocity, the other extreame is animated with an extreame swift motion. Which for the better understanding of it we will explain, resuming a Scheme like to the former; in which if we do but suppose a tract of Sea to be long, *v. g.* a fourth part, as is the arch *BC* [in Fig. 2.] because the parts *B* are, as hath been already declared, very swift in motion, by reason of the union of the two motions diurnal and annual, towards one and the same way, but

but the part C at the same time is retarded in its motion, as being deprived of the progression dependant on the diurnal motion: If we suppose, I say, a tract of Sea as long as the arch B C, we have already seen, that its extrems shall move in the same time with great inequality. And extreamly different would the velocities of a tract of Sea be that is in length a semicircle, and placed in the position B C D, in regard that the extream B would be in a most accelerate motion, and the other D, in a most slow one; and the intermediate parts towards C, would be in a moderate motion. And according as the said tracts of Sea shall be shorter, they shall lesse participate of this extravagant accident, of being in some hours of the day with their parts diversly affected by velocity and tardity of motion. So that, if, as in the first case, we see by experience that the acceleration and retardation, though equally imparted to all the parts of the containing Vessel, is the cause that the water contained, fluctuates too and again, what may we think would happen in a Vessel so admirably disposed, that retardation and acceleration of motion is very unequally contributed to its parts? Certainly we must needs grant that greater and more wonderful causes of the commotions in the Water ought to be looked for. And though it may seem impossible to some, that in artificial Machines and Vessels we should be able to experiment the effects of such an accident; yet nevertheless it is not absolutely impossible to be done; and I have by me the model of an Engine, in which the effect of these admirable commixtions of motions may be particularly observed. But as to what concerns our present purpose, that which you may have hitherto comprehended with your imagination may suffice.

S A G R. I for my own particular very well conceive that this admirable accident ought necessarily to even in the Straights of Seas, and especially in those that distend themselves for a great length from West to East; namely according to the course of the motions of the Terrestrial Globe; and as it is in a certain manner unthought of, and without a president among the motions possible to be made by us; so it is not hard for me to believe, that effects may be derived from the same, which are not to be imitated by our artificial experiments.

S A L V. These things being declared, it is time that we proceed to examine the particular accidents, which, together with their diversities, are observed by experience in the ebbing and flowing of the waters. And first we need not think it hard to guess whence it happeneth, that in Lakes, Pooles, and also in the lesser Seas there is no notable flux and reflux; the which hath two very solid reasons. The one is, that by reason of the short-

D d d

ness

Reasons renewed of the particular accidents observed in the ebbings and flowings.

*Second causes
why in small Seas
and in Lakes there
are no ebbs and
flowings.*

ness of the Vessel, in its acquiring in several hours of the day several degrees of velocity, they are with very little difference acquired by all its parts; for as well the precedent as the subsequent, that is to say, both the Eastern and Western parts, do accelerate and retard almost in the same manner; and withal making that alteration by little and little, and not by giving the motion of the containing Vessel a sudden check, and retardment, or a sudden and great impulse or acceleration; both it and all its parts, come to be gently and equally impressed with the same degrees of velocity; from which uniformity it followeth, that also the contained water with but small resistance and opposition, receiveth the same impressions; and by consequence doth give but very obscure signes of its rising or falling, or of its running towards one part or another. The which effect is likewise manifestly to be seen in the little artificial Vessels; wherein the contained water doth receive the self same impressions of velocity; when ever the acceleration and retardation is made by gentle and uniform proportion. But in the Straights and Bays that for a great length distend themselves from East to West, the acceleration and retardation is more notable and more uneven; for that one of its extrems shall be much retarded in motion, and the other shall at the same time move very swiftly: The reciprocal libration or levelling of the water proceeding from the *impetus* that it had conceived from the motion of its container. The which libration, as hath been noted, hath its undulations very frequent in small Vessels; from whence ensues, that though there do reside in the Terrestrial motions the cause of conferring on the waters a motion onely from twelve hours to twelve hours, for that the motion of the containing Vessels do extremely accelerate and extremely retard but once every day, and no more; yet nevertheless this same second cause depending on the gravity of the water which striveth to reduce it self to equilibration, and that according to the shortness of the Vessel hath its reciprocations of one, two, three, or more hours; this intermixing with the first, which also it self in small Vessels is very little, it becometh upon the whole altogether insensible. For the primary cause, which hath the periods of twelve hours, having not made an end of imprinting the precedent commotion, it is overtaken and opposed by the other second, dependant on the waters own weight, which according to the brevity and profundity of the Vessel, hath the time of its undulations of one, two, three, four, or more hours; and this contending with the other former one, disturbeth and removeth it, not permitting it to come to the height, no nor to the half of its motion; and by this contestation the evidence of the ebbing and flow-

flowing is wholly annihilated, or at least very much obscured. I passe by the continual alteration of the air, which disquieting the water, permits us not to come to a certainty, whether any, though but small, increase or abatement of half an inch, or lesse, do reside in the Straights, or receptacles of water not above a degree or two in length.

I come in the second place to resolve the question, why, there not residing any vertue in the primary principle of commoving the waters, save onely every twelve hours, that is to say, once by the greatest velocity, and once by the greatest tardity of motion; the ebbings and flowings should yet neverthelesse appear to be every six hours. To which is answered, that this determination cannot any wayes be taken from the primary cause onely; but there is a necessity of introducing the secondary causes, as namely the greater or lesse length of the Vessels, and the greater or lesse depth of the waters in them contained. Which causes although they have not any operation in the motions of the waters, those operations belonging to the sole primary cause, without which no ebbing or flowing would happen, yet neverthelesse they have a principal share in determining the times or periods of the reciprocations, and herein their influence is so powerful, that the primary cause must of force give way unto them. The period of six hours therefore is no more proper or natural than those of other intervals of times, though indeed its the most observed, as agreeing with our Mediterrane, which was the onely Sea that for many Ages was navigated: though neither is that period observed in all its parts; for that in some more angust places, such as are the *Hellspont*, and the *Aegean Sea*, the periods are much shorter, and also very divers amongst themselves; for which diversities, and their causes incomprehensible to *Aristotle*, some say, that after he had a long time observed it upon some cliffes of *Negropont*, being brought to desperation, he threw himself into the adjoyning *Euripus*, and voluntarily drowned himself.

The reason given, why the ebbings and flowings, for the most parts, are every six hours.

In the third place we have the reason ready at hand, whence it commeth to passe, that some Seas, although very long, as is the Red Sea, are almost altogether exempt from Tides, which happeneth because their length extendeth not from East to West, but rather transversly from the Southeast to the Northwest; but the motions of the Earth going from West to East; the impulses of the water, by that means, alwayes happen to fall in the Meridians, and do not move from parallel to parallel; insomuch that in the Seas that extend themselves athwart towards the Poles, and that the contrary way are narrow, there is

The cause why some Seas, though very long, suffer no ebbing and flowing.

D d d 2

no

no cause of ebbing and flowing, save onely by the participation of another Sea, wherewith it hath communication, that is subject to great commotions.

Ebbings and flowings why greatest in the extremities of Gulphs, and least in the middle parts.

In the fourth place we shall very easily find out the reason why the fluxes and refluxes are greatest, as to the waters rising and falling in the utmost extremities of Gulphs, and least in the intermediate parts; as daily experience sheweth here in *Venice*, lying in the farther end of the *Adriatick* Sea, where that difference commonly amounts to five or six feet; but in the places of the *Mediterrane*, far distant from the extreame, that mutation is very small, as in the *Isles of Corsica* and *Sardinia*, and in the *Strands of Rome* and *Ligorne*, where it exceeds not half a foot; we shall understand also, why on the contrary, where the risings and fallings are small, the courses and recourses are great: I say it is an easie thing to understand the causes of these accidents, seeing that we meet with many manifest occurrences of the same nature in every kind of Vessel by us artificially composed, in which the same effects are observed naturally to follow upon our moving it unevenly, that is, one while faster, and another while slower.

Why in narrow places the course of the waters is more swift than in larger.

Moreover, considering in the fifth place, that the same quantity of Water being moved, though but gently, in a spacious Channel, coming afterwards to go through a narrow passage, will of necessity run with great violence, we shall not finde it hard to comprehend the cause of the great Currents that are made in the narrow Channel that separateth *Calabria* from *Sicilia*: for that all the Water that, by the spaciousness of the *Isle*, and by the *Ionick* Gulph, happens to be pent in the Eastern part of the Sea, though it do in that, by reason of its largeness, gently descend towards the West, yet nevertheless, in that it is pent up in the *Bosphorus*, it floweth with great violence between *Spilla* and *Caribdis*, and maketh a great agitation. Like to which, and much greater, is said to be betwixt *Africa* and the great *Isle of St. Lorenzo*, where the Waters of the two vast Seas, *Indian* and *Ethiopic*, that lie round it, must needs be straightned into a lesse Channel between the said *Isle* and the *Ethiopian Coast*. And the Currents must needs be very great in the Straights of *Magellanes*, which joyn together the vast Oceans of *Ethiopia*, and *Del Zur*, called also the *Pacifick* Sea.

A discussion of some more abstruse accidents observed in the ebbing and flowing.

It follows now, in the sixth place, that to render a reason of some more abstruse and incredible accidents, which are observed upon this occasion, we make a considerable reflection upon the two principal causes of ebbings and flowings, afterwards compounding and mixing them together. The first and simplest of

of which is (as hath often been said) the determinate acceleration and retardation of the parts of the Earth, from whence the Waters have a determinate period put to their decursions towards the East, and return towards the West, in the time of twenty four hours. The other is that which dependeth on the proper gravity of the Water, which being once commoved by the primary cause, seeketh, in the next place, to reduce it self to *Æquilibrium*, with iterated reciprocations; which are not determined by one sole and prefixed time; but have as many varieties of times as are the different lengths and profundities of the receptacles, and Straights of Seas; and by what dependeth on this second principle, they would ebbe and flow, some in one hour, others in two, in four, in six, in eight, in ten, &c. Now if we begin to put together the first cause, which hath its set Period from twelve hours to twelve hours, with some one of the secondary, that hath its Period *verb. grat.* from five hours to five hours, it would come to passe, that at sometimes the primary cause and secondary would accord to make impulses both one and the same way; and in this concurrency, and (as one may call it) unanimous conspiracy the flowings shall be great. At other times it happening that the primary impulse doth, in a certain manner, oppose that which the secondary Period would make, and in this contest one of the Principles being taken away, that which the other would give, will weaken the commotion of the Waters, and the Sea will return to a very tranquil State, and almost immoveable. And at other times, according as the two aforesaid Principles shall neither altogether contest, nor altogether concur, there shall be other kinds of alterations made in the increase and diminution of the ebbing and flowing. It may likewise fall out that two Seas, considerably great and which communicate by some narrow Channel, may chance to have, by reason of the mixtion of the two Principles of motion, one cause to flow at the time that the other hath cause to move a contrary way; in which case in the Channel, whereby they imbogue themselves into each other, there do extraordinary conturbations insue, with opposite and vortick motions, and most dangerous boillings and breakings, as frequent relations and experiences do assure us. From such like discordant motions, dependent not onely on the different positions and longitudes, but very much also upon the different profundities of the Seas, which have the said intercourse there do happen at sometimes different commotions in the Waters, irregular, and that can be reduced to no rules of observation, the reasons of which have much troubled, and alwayes do trouble Mariners, for that they meet with them without seeing either impulse of winds, or other

other eminent areal alteration that might occasion the same; of which disturbance of the Air we ought to make great account in other accidents, and to take it for a third and accidental cause, able to alter very much the observation of the effects depending on the secondary and more essential causes. And it is not to be doubted, but that impetuous windes, continuing to blow, for example, from the East, they shall retain the Waters and prohibit the reflux or ebbing; whereupon the second and third reply of the flux or tide overtaking the former, at the hours prefixed, they will swell very high; and being thus born up for some dayes, by the strength of the Winds, they shall rise more than usual, making extraordinary inundations.

The cause why, in some narrow Channels, we see the Sea-water run alwayes one way.

** Or currents.*

We ought also, (and this shall serve for a seventh Probleme) to take notice of another cause of motion dependant on the great abundance of the Waters of great Rivers that discharge themselves into Seas of no great capacity, whereupon in the Straits or *Bosphori* that communicate with those Seas, the Waters are seen to run always one way: as it happeneth in the *Thracian Bosphorus* below *Constantinople*, where the water alwayes runneth from the *Black-Sea*, towards the *Propontis*: For in the said *Black-Sea* by reason of its shortnesse, the principal causes of ebbing and flowing are but of small force. But, on the contrary, very great Rivers falling into the same, those huge fluxions of water being to passe and disgorge themselves by the Straits, the course is there very notable and alwayes towards the South. Where moreover we ought to take notice, that the said Strait or Channel, albeit very narrow, is not subject to perturbations, as the Strait of *Scilla* and *Carybdis*; for that that hath the *Black-Sea* above towards the North, and the *Propontis*, the *Aegean*, and the *Mediterranean* Seas joyned unto it, though by a long tract towards the South; but now, as we have observed, the Seas, though of never so great length, lying North and South, are not much subject to ebbings and flowings; but because the *Sicilian* Strait is situate between the parts of the *Mediterrane* distended for a long tract or distance from West to East, that is, according to the course of the fluxes and refluxes; therefore in this the agitations are very great; and would be much more violent between *Hercules Pillars*, in case the Strait of *Gibraltar* did open lesse; and those of the Strait of *Magellanes* are reported to be extraordinary violent.

This is what, for the present, cometh into my mind to say unto you about the causes of this first period diurnal of the Tide, and its various accidents; touching which, if you have any thing to offer, you may let us hear it, that so we may afterwards proceed to the other two periods, monethly and annual.

S I M P.

SIMP. In my opinion, it cannot be denied, but that your discourse carrieth with it much of probability, arguing, as we say, *ex suppositione*, namely, granting that the Earth moveth with the two motions assigned it by *Copernicus*: but if that motion be disproved, all that you have said is vain, and insignificant: and for the disproval of that *Hypothesis*, it is very manifestly hinted by your Discourse it self. You, with the supposition of the two Terrestrial motions, give a reason of the ebbing and flowing; and then again, arguing circularly, from the ebbing and flowing, draw the reason and confirmation of those very motions; and so proceeding to a more specious Discourse, you say that the Water, as being a fluid body, and not tenaciously annexed to the Earth, is not constrained punctually to obey every of its motions, from which you afterwards infer its ebbing and flowing. Now I, according to your own method, argue the quite contrary, and say; the Air is much more tenuous, and fluid than the Water; and lesse annexed to the Earths superficies, to which the Water, if it be for nothing else, yet by reason of its gravity that presseth down upon the same more than the light Air; adhereth; therefore the Air is much obliged to follow the motions of the Earth: and therefore were it so, that the Earth did move in that manner, we the inhabitants of it, and carried round with like velocity by it, ought perpetually to feel a Winde from the East that beateth upon us with intolerable force. And that so it ought to fall out, quotidian experience assureth us: for if, with onely riding post, at the speed of eight or ten miles an hour in the tranquil Air, the incountering of it with our face seemeth to us a Winde that doth not lightly blow upon us; what should we expect from our rapid course of 800. or a thousand miles an hour; against the Air, that is, free from that motion? And yet notwithstanding we cannot perceive any thing of that nature.

The Hypothesis of the Earths mobility taken in favour of the Tide, opposed.

SALV. To this objection that hath much of likelihood in it, I reply, that its true, the Air is of greater tenuity and levity; and, by reason of its levity, lesse adherent to the Earth than Water so much more grave and bulky; but yet the consequence is false that you infer from these qualities; namely, that upon account of that its levity, tenuity, and lesse adherence to the Earth, it should be more exempt than the Water from following the Terrestrial Motions; so as that to us, who absolutely partake of of them, the said exemption should be sensible and manifest; nay, it happeneth quite contrary; for, if you well remember, the cause of the ebbing and flowing of the Water assigned by us, consisteth in the Waters not following the unevennesse of the motion of its Vessel, but retaining the *impetus* conceived before, without

The answer to the objections made against the motion of the Terrestrial Globe.

† Corpulent.

The Water more apt to conserve an impetus conceived, then the Air.

without diminishing or increasing it according to the precise rate of its diminishing or increasing in its Vessel. Because therefore that in the conservation and retention of the *impetus* before conceived, the disobedience to a new augmentation or diminution of motion consisteth, that moveable that shall be most apt for such a retention, shall be also most commodious to demonstrate the effect that followeth in consequence of that retention. Now how much the Water is disposed to maintain such a conceived agitation; though the causes cease that impress the same, the experience of the Seas extremely disturbed by impetuous Winds sheweth us; the Billows of which, though the Air be grown calm, and the Wind laid, for a long time after continue in motion: As the Sacred Poet pleasantly sings,

Qual l'alto Egeo, &c.——

Light bodies easier to be moved than heavy, but less apt to conserve the motion.

And that long continuing rough after a storm, dependeth on the gravity of the water: For, as I have elsewhere said, light bodies are much easier to be moved than the more grave, but yet are so much the less apt to conserve the motion imparted, when once the moving cause ceaseth. Whence it comes that the Air, as being of it self very light and thin, is easily mov'd by any very small force, yet it is withall very unable to hold on its motion, the Mover once ceasing. Therefore, as to the Air which environs the Terrestrial Globe, I would say, that by reason of its adherence, it is no less carried about therewith than the Water; and especially that part which is contained in its vessels; which vessels are the valleys enclosed with Mountains. And we may with much more reason affirm that this same part of the Air is carried round, and born forwards by the rugged parts of the Earth, than that the higher is whirld about by the motion of the Heavens, as ye *Peripateticks* maintain.

Its more rational that the Air be commoved by the rugged surface of the Earth, than by the Celestial motion.

The revolution of the Earth confirmed by a new argument taken from the Air.

What hath been hitherto spoken, seems to me a sufficient answer to the allegation of *Simplinius*; yet nevertheless with a new instance and solution, founded upon an admirable experiment, I will superabundantly satisfy him, and confirm to *Sagredus* the mobility of the Earth. I have told you that the Air, and in particular that part of it which ascendeth not above the tops of the highest Mountains, is carried round by the uneven parts of the Earths surface: from whence it should seem, that it must of consequence come to passe, that in case the superficies of the Earth were not uneven; but smooth and plain, no cause would remain for drawing the Air along with it, or at least for revolving it with so much uniformity. Now the surface of this our Globe, is not all craggy and rugged, but there are exceeding great tracts very even,

even, to wits the surfaces of very vast Seas, which being also far remote from the continue ledges of Mountains which environ it, seem to have no faculty of carrying the super-ambient Air along therewith: and not carrying it about, we may perceive what will of consequence ensue in those places.

SIMP. I was about to propose the very same difficulty, which I think is of great validity.

SALV. You say very well *Simplicius*, for from the not finding in the Air that which of consequence would follow, did this our Globe move round; you argue its immovableness. But in case that this which you think ought of necessary consequence to be found, be indeed by experience proved to be so; will you accept it for a sufficient testimony and an argument for the mobility of the said Globe?

SIMP. In this case it is not requisite to argue with me alone, for if it should so fall out, and that I could not comprehend the cause thereof, yet haply it might be known by others.

SALV. So that by playing with you, a man shall never get, but be alwayes on the losing hand; and therefore it would be better to give over. Nevertheless, that we may not cheat our third man we will play on. We said even now, and with some addition we reiterate it, that the Air as if it were a thin and fluid body, and not solidly conjoynd with the Earth, seem'd not to be necessitated to obey its motion; unlesse so far as the cragginess of the terrestrial superficies, transports and carries with it a part thereof contiguous thereunto; which doth not by any great space exceed the greatest altitude of Mountains: the which portion of Air ought to be so much less repugnant to the terrestrial conversion, by how much it is repleat with vapours, fumes, and exhalations, matters all participating of terrene qualities, and consequently apt of their own nature to the same motions. But where there are wanting the causes of motion, that is, where the surface of the Globe hath great levels, and where there is less mixture of the terrene vapours, there the cause whereby the ambient Air is constrained to give entire obedience to the terrestrial conversion will cease in part; so that in such places, whilst the Earth revolveth towards the East, there will be continually a wind perceived which will beat upon us, blowing from the East towards the West: and such gales will be the more sensible, where the revolution of the Globe is most swift; which will be in places more remote from the Poles, and approaching to the greatest Circle of the diurnal conversion. But now *de facto* experience much confirmeth this Philosophical argumentation; for in the spacious Seas, and in their parts most remote from Land, and situate under the Torrid Zone, that is bounded by the Tropicks, where there are none of those

The vaporous parts of the earth, partake of its motions.

E e e

same

*Constant gales
within the Tro-
picks blow towards
the West.*

*The course to the
West-India's ea-
sies the return dis-
cuss.*

*Winds from Land
make rough the
Seas.*

*Another observa-
tion taken from the
Air in confirmati-
on of the motion of
the Earth.*

** Which Wind
with our English
Mariners is called
the Trade-wind.*

same terrestrial evaporations, we finde a perpetual gale move from the East with so constant a blast, that ships by favour thereof sail prosperously to the *West-India's*. And from the same coasting along the *Mexican* shore, they with the same felicity pass the *Pacifick* Ocean towards the *India's*; which to us are East, but to them are West. Whereas on the contrary the Course from thence towards the East is difficult and uncertain, and not to be made by the same Rhumb, but must vere more to Land-ward, to recover other Winds, which we may call accidentary and tumultuary, produced from other Principles, as those that inhabit the continent find by experience. Of which productions of Winds, the Causes are many and different, which shall not at this time be mentioned. And these accidentary Winds are those which blow indifferently from all parts of the Earth, and make rough the Seas remote from the Equinoctial, and environed by the rugged Surface of the Earth; which is as much as to say environ'd with those perturbations of Air, that confound that primary Gale. The which, in case these accidental impediments were removed, would be continually felt, and especially upon the Sea. Now see how the effect of the Water and Air seem wonderfully to accord with the Celestial observations, to confirm the mobility of our Terrestrial Globe.

SALGRV. I also for a final close will relate to you one particular, which as I believe is unknown unto you, and which likewise may serve to confirm the same conclusion: You *Salviatus* alledged, That Accident which Sailers meet with between the Tropicks; I mean that perpetual Gale of Winde that beats upon them from the East, of which I have an account from those that have many times made the Voyage: And moreover (which is very observable) I understand that the Mariners do not call it a *Wind*, but by another * name, which I do not now remember, taken haply from its so fixed and constant Tenor; which when they have met with, they tie up their shrouds and other cordage belonging to the Sails, and without any more need of touching them, though they be in a sleep, they can continue their course. Now this constant Trade-wind was known to be such by its continual blowing without interruptions; for if it were interrupted by other Windes, it would not have been acknowledged for a singular Effect, and different from the rest: from which I will infer, That it may be that also our Mediterranean Sea doth partake of the like accident; but it is not observed, as being frequently altered by the confluence of other windes. And this I say, not without good grounds, yea upon very probable conjectures which came unto my knowledge, from that which tendred it self to my notice on occasion of the voyage that I made into *Syria*, going Consul for this Nation to

to *Aleppo*, and this it is: That keeping a particular account and memorial of the dayes of the departure and arrival of the Ships in the Ports of *Alexandria*, of *Alexandretta*, and this of *Venice*; in comparing sundry of them, which I did for my curiosity, I found that in exactness of account the returns hither, that is the voiajes from East to West along the Mediterrane, are made in less time then the contrary courses by 25. in the Hundred: So that we see that one with another, the Eastern windes are stronger then the Western.

The voiajes in the Mediterrane from East to West are made in shorter times than from West to East.

SALV. I am very glad I know this particular, which doth not a little make for the confirmation of the Earths mobility. And although it may be alledged, That all the Water of the Mediterrane runs perpetually towards the Straits-mouth, as being to disimbogues into the Ocean, the waters of as many Rivers, as do discharge themselves into the same; I do not think that that current can be so great, as to be able of it self alone to make so notable a difference: which is also manifest by observing that the water in the *Pharo* of *Sicily* runneth back again no less towards the East, than it runneth forwards towards the West.

SAGR. I, that have not as *Simplicius*, an inclination to satisfie any one besides my self, am satisfied with what hath been said as to this first particular: Therefore *Salviatus*, when you think it fit to proceed forward, I am prepared to hear you.

SALV. I shall do as you command me, but yet I would fain hear the opinion also of *Simplicius*, from whose judgement I can argue how much I may promise to my self touching these discourses from the *Peripatetick* Schools, if ever they should come to their ears.

SIMP. I desire not that my opinion should serve or stand for a measure, whereby you should judge of others thoughts; for as I have often said, I am inconsiderable in these kinde of studies, and such things may come into the mindes of those that are entered into the deepest passages of Philosophy, as I could never think of; as having (according to the Proverb) scarce kist her Maid: yet nevertheless, to give you my sudden thoughts, I shall tell you, That of those effects by you recounted, and particularly the last, there may in my judgement very sufficient Reasons be given without the Earths mobility, by the mobility of the Heavens only; never introducing any novelty more, than the inversion of that which you your self propose unto us. It hath been received by the *Peripatetick* Schools, that the Element of Fire, and also a great part of the Aire is carried about according to the Diurnal conversion from East to West, by the contact of the Concave of the Lunar Orb, as by the Vessel their container. Now without going out of your track, I will that we determine the Quantity of

It is demonstrated inverting the argument, that the perpetual motion of the Air from East to West cometh from the motion of Heaven.

*It is demonstrated
inverting the ar-
gument, that the
perpetual motion of
the Air from East
to West, cometh
from the motion of
Heaven.*

*The motion of the
Water dependeth
on the motion of
Heaven.*

*The flux and re-
flux may depend
on the diurnal mo-
tion of Heaven.*

the Aire which partaketh of that motion to distend so low as to the Tops of the highest Hills, and that likewise they would reach to the Earth, if those Mountains did not impede them, which agreeth with what you say: For as you affirm, the Air, which is invironed by ledges of Mountains, to be carried about by the asperity of the moveable Earth; we on the contrary say, That the whole Element of Air is carried about by the motion of Heaven, that part only excepted which lyeth below those bodies, which is hindered by the asperity of the immoveable Earth. And whereas you said, That in case that asperity should be removed, the Air would also cease to be whirled about; we may say, That the said asperity being removed, the whole Aire would continue its motion. Whereupon, because the surfaces of spacious Seas are smooth, and even; the Airs motion shall continue upon those, alwaies blowing from the East: And this is more sensibly perceived in Climates lying under the Line, and within the Tropicks, where the motion of Heaven is swifter; and like as that Celestial motion is able to bear before it all the Air that is at liberty, so we may very rationally affirm that it contributeth the same motion to the Water moveable, as being fluid and not connected to the immobility of the Earth: And with so much the more confidence may we affirm the same, in that by your confession, that motion ought to be very small in respect of the efficient Cause; which begirring in a natural day the whole Terrestrial Globe, passeth many hundreds of miles an hour, and especially towards the Equinoctial; whereas in the currents of the open Sea, it moveth but very few miles an hour. And thus the voiajes towards the West shall come to be commodious and expeditious, not onely by reason of the perpetual Eastern Gale, but of the course also of the Waters; from which course also perhaps the Ebbing and Flowing may come, by reason of the different scituation of the Terrestrial Shores: against which the Water coming to beat, may also return backwards with a contrary motion, like as experience sheweth us in the course of Rivers; for according as the Water in the unevenness of the Banks, meeteth with some parts that stand out, or make with their Meanders some Reach or Bay, here the Water turneth again, and is seen to retreat back a considerable space. Upon this I hold, That of those effects from which you argue the Earths mobility, and alledge it as a cause of them, there may be assigned a cause sufficiently valid, retaining the Earth stedfast, and restoring the mobility of Heaven.

S A I V. It cannot be denied, but that your discourse is ingenious, & hath much of probability, I mean probability in appearance, but not in reality & existence: It consisteth of two parts: In the first it assigneth

assignes a reason of the continual motion of the Eastern Windes and also of a like motion in the Water. In the second, It would draw from the same Source the cause of the Ebbing and Flowing. The first part hath (as I have said) some appearance of probability, but yet extremely less then that which we take from the Terrestrial motion. The second is not onely wholly improbable, but altogether impossible and false. And coming to the first, whereas it is said that the Concave of the Moon carrieth about the element of Fire, and the whole Air, even to the tops of the higher Mountains. I answer first, that it is dubious whether there be any element of Fire: But suppose there be, it is much doubted of the Orbe of the Moon, as also of all the rest; that is, Whether there be any such solid bodies and vast, or els, Whether beyond the Air there be extended a continue expansion of a substance of much more tenuity and purity than our Air, up and down which the Planets go wandring, as now at last a good part of those very Phylsophers begin to think: But be it in this or in that manner, there is no reason for which the Fire, by a simple contract to a superficies, which you your self grant to be smooth and terse, should be according to its whole depth carried round in a motion different from its natural inclination; as hath been defusely proved, and with sensible reasons demonstrated by *Il Saggiatore*: Besides the other improbability of the said motions transfusing it self from the subtilest Fire throughout the Air, much more dense; and from that also again to the Water. But that a body of rugged and mountainous surface, by revolving in it self, should carry with it the Air contiguous to it, and against which its promontaries beat, is not onely probable but necessary, and experience thereof may be daily seen; though without seeing it, I believe that there is no judgement that doubts thereof. As to the other part, supposing that the motion of Heaven did carry round the Air, and also the Water; yet would that motion for all that have nothing to do with the Ebbing and Flowing. For being that from one onely and uniform cause, there can follow but one sole and uniform effect; that which should be discovered in the Water, would be a continue and uniform course from East to West; and in that a Sea onely, which running compass environeth the whole Globe. But in determinate Seas, such as is the Mediterranean shut up in the East, there could be no such motion. For if its Water might be driven by the course of Heaven towards the West, it would have been dry many ages since: Besides that our Water runneth not onely towards the West, But returneth backwards towards the East, and that in ordinal Periods: And whereas you say by the example of Rivers, that though the course of the Sea were Originally that onely from

A reason of the continual motion of the Air and Water may be given, making the Earth moveable, then by making it immovable.

It is improbable that the element of Fire should be carried round by the Concave of the Moon.

** A Treatise of our Author formerly cited.*

The Ebbing and Flowing cannot depend on the motion of Heaven.

from East to West, yet nevertheless the different Position of the Shores may make part of the Water regurgitate, and return backwards: I grant it you, but it is necessary that you take notice my *Simplicius*, that where the Water upon that account returneth backwards, it doth so there perpetually; and where it runneth straight forwards, it runneth there alwayes in the same manner; for so the example of the Rivers shewes you: But in the case of the ebbing and flowing, you must finde and give us some reason why it doth in the self same place run one while one way, and another while another; Effects that being contrary & irregular, can never be deduced from any uniform and constant Cause: And this Argument, that overthrowes the Hypothesis of the motion contributed to the Sea from the Heavens diurnal motion, doth also confute that Position of those who would admit the sole diurnal motion of the Earth, and believe that they are able with that alone to give a reason of the Flux and Reflux: Of which effect since it is irregular, the cause must of necessity be irregular and alterable.

SIMP. I have nothing to reply, neither of my own, by reason of the weakness of my understanding; nor of that of others, for that the Opinion is so new: But I could believe that if it were spread amongst the Schools, there would not want Phylosophers able to oppose it.

SAGR. Expect such an occasion; and we in the mean time if it seem good to *Salviatus*, will proceed forward.

SALV. All that which hath been said hitherto, pertaineth to the diurnal period of the ebbing and flowing; of which we have in the first place demonstrated in general the primary and universal Cause, without which, no such effect would follow: Afterward passing to the particular Accidents, various, and in a certain sort irregular, that are observed therein: We have handled the secondary and concomitant Causes upon which they depend. Now follow the two other Periods, Monethly, and Annual, which do not bring with them new and different Accidents, other than those already considered in the diurnal Period; but they operate on the same Accidents, by rendring them greater and lesser in several parts of the Lunar Moneth; and in several times of the Solar Year; as if that the Moon and Sun did each conceive it self apart in operating and producing of those Effects; a thing that totally clasheth with my understanding, which seeing how that this of Seas is a local and sensible motion, made in an immense mass of Water, it cannot be brought to subscribe to Lights, to temperate Heats, to predominacies by occult Qualities, and to such like vain Imaginations, that are so far from being, or being possible to be Causes of the Tide; that on the contrary

rary, the Tide is the cause of them, that is, of bringing them into the brains more apt for loquacity and ostentation, than for the speculation and discovering of the more abstruse secrets of Nature; which kind of people, before they can be brought to pronounce that wise, ingenious, and modest sentence, *I know it not*, suffer to escape from their mouths and pens all manner of extravagancies. And the onely observing, that the same Moon, and the same Sun operate not with their light with their motion, with great heat, or with temperate, on the lesser receptacles of Water, but that to effect their flowing by heat, they must be reduced to little lesse than boiling, and in short, we not being able artificially to imitate any way the motions of the Tide, save only by the motion of the Vessel, ought it not to satisfie every one, that all the other things alledged, as causes of those effects, are vaine fancies, and altogether estranged from the Truth. I say, therefore, that if it be true, that of one effect there is but one sole primary cause, and that between the cause and effect, there is a firm and constant connection; it is necessary that whenever there is seen a firm and constant alteration in the effect, there be a firm and constant alteration in the cause. And because the alterations that happen in the ebbing and flowing in several parts of the Year and Moneths, have their periods firm and constant, it is necessary to say, that a regular alteration in those same times happeneth in the primary cause of the ebbings and flowings. And as for the alteration that in those times happens in the ebbings and flowings consisteth onely in their greatness; that is, in the Waters rising and falling more or lesse, and in running with greater or lesse *impetus*; therefore it is necessary, that that which is the primary cause of the ebbing and flowing, doth in those same determinate times increase and diminish its force. But we have already concluded upon the inequality and irregularity of the motion of the Vessels containing the Water to be the primary cause of the ebbings and flowings. Therefore it is necessary, that that irregularity, from time to time, correspondently grow more irregular, that is, grow greater and lesser. Now it is requisite, that we call to minde, that the irregularity, that is, the different velocity of the motions of the Vessels, to wit, of the parts of the Terrestrial Superficies, dependeth on their moving with a compound motion, resulting from the combination of the two motions, Annual and Diurnal, proper to the whole Terrestrial Globe; of which the Diurnal conversion, by one while adding to, and another while subtracting from, the Annual motion, is that which produceth the irregularity in the compound motion; so that, in the additions and subtractions, that the Diurnal revolution maketh from the Annual motion,

The alterations in the effects argue alteration in the cause.

The causes at large assigned of the Periods Monthly and Annual of the ebbings and flowings.

con-

The monthly
and annual altera-
tions of the tide can
depend upon no-
thing, save on the
alteration of the
additions & sub-
stractions of the
diurnal period from
the annual.

consisteth the original cause of the irregular motion of the Vessels, and consequently of the Ebbing and Flowing: insomuch that if these additions and substractions should alwayes proceed in the same proportion, in respect of the Annual motion, the cause of the Ebbing and Flowing would indeed continue, but yet so as that they would perpetually return in the self same manner: But we are to finde out the cause of making the same Ebblings and Flowings in divers times greater and lesser: Therefore we must (if we will retain the identity of the cause) find the alteration in these additions and substractions, that make them more & less potent, in producing those effects which depend thereupon. But I see not how that potency and impotence can be introduced, unlesse by making the same additions and substractions, one while greater, and another while lesser; so that the acceleration and the retardment of the compound motion, may be made, sometimes in greater, and sometimes in lesser proportion.

SALV. I feel my self very gently led, as it were, by the hand, and though I finde no rubs in the way, yet nevertheless, like a blind-man, I see not whether your Clue leadeth me, nor can I imagine where such a Journey will end.

SALV. Though there be a great difference between my slow pac't Philosophy, and your more nimble Reason, yet nevertheless, in this particular which we are now upon, I do not much wonder, if the apprehensiveness of your wit be a little obscured by the dark and thick mist that hides the mark, at which we aime: and that which lesseneth my admiration is, the remembrance of the many hours, many dayes, yea more, many nights that I have consumed in this contemplation, and of the many times that, despairing to bring it to a period, I have, for an encouragement of my self, indeavoured to believe, by the example of the unfortunate *Orlando*, that that might not possibly be true, which yet the testimony of so many credible men set before my Eyes: wonder not, therefore, if this once, contrary to your custome, you do not foresee what I intend: and if you will needs admire, I believe that the event, as far as I can judge unexpected, will make you cease your wonderment.

SALV. I thank God, that he did not permit that desperation of yours to end in the *Exit* that is fabled of the miserable *Orlando*, nor in that which haply is no lesse fabulously related of *Aristotle*, that someither my self nor others should be deprived of the discovery of a thing, as abstruse as it was desirable: I beseech you, therefore, to satissie my eager appetite as soon as you can.

SALV. I am ready to serve you: We were upon an inquiry in what manner the additions and substractions of the Terrestrial

all

all conversion from the Annual motion, could be made, one while in a greater, and another while in a lesser proportion; which diversity, and no other thing, could be assigned for the cause of the alterations, Monethly and Annual, that are seen in the greatnesse of the Ebbings and Flowings. I will now consider how this proportion of the additions and substractions of the Diurnal Revolution, and Annual motion may grow greater and lesser three several wayes. One is by increasing and diminishing the velocity of the Annual motion, retaining the additions and substractions made by the Diurnal conversion in the same greatnesse, because the Annual motion being about three times greater, that is, more velocious than the Diurnal motion (considered likewise in the Grand Circle) if we increase it anew, the additions and substractions of the Diurnal motion will occasion lesse alteration therein: but, on the other side, making it more slow, it will be altered in greater proportion, by that same diurnal motion, just as the adding or substracting four degrees of velocity from one that moveth with twenty degrees, altereth his course lesse, than those very four degrees would do, added or substracted from one that should move onely with ten degrees. The second way would be, by making the additions and substractions greater and lesser, retaining the annual motion in the same velocity; which is as easie to be understood, as it is manifest, that a velocity *v. gr.* of 20. degr. is more altered by the addition or substraction of 10. deg. than by the addition or substraction of 4. The third way would be, in case these two were joyned together, diminishing the annual motion, & increasing the diurnal additions and substractions. Hitherto, as you see, it was no hard matter to attain, but yet it proved to me very hard to find by what means this might be effected in Nature. Yet in the end, I finde that she doth admirably make use thereof, and in wayes almost incredible: I mean, admirable and incredible to us, but not to her, who worketh even those very things, which, to our capacity, are of infinite wonder, with extraordinary facility and simplicity; and that which it is hard for us to understand, is easie for her to effect. Now to proceed, having shewn that the proportion between the additions and substractions of the Diurnal conversion and Annual motion may be made greater and lesser, two wayes, (and I say two, because the third is comprized in the two first) I adde, that Nature maketh use of them both: and farthermore, I subjoyn, that if she did make use but of one alone, it would be necessary to take away one of the two Periodical alterations. That of the Monethly Period would cease, if the annual motion should not alter. And in case the additions and substractions of the diurnal revolution should continually be

Three wayes of altering the proportion of the additions of the diurnal Revolution to the annual motion.

That which to us is hard to be understood, is with Nature easie to be effected.

If the Diurnal motion should not alter, the annual Period would cease

F f f

be equal, the alterations of the annual Period would fail.

SAGR. It seems then, that the Monethly alteration of ebbings and flowings dependeth on the alteration of the annual motion of the Earth? And the annual alteration of those ebbings and flowings do, it seems, depend on the additions and subtractions of the diurnal conversion? And here now I finde my self worse puzzled than before, and more out of hope of being able to comprehend how this intricacy may be, which is more inextricable, in my judgment, than the Gordian knot. And I envy *Simplicius*, from whose silence I argue that he doth apprehend the whole businesse, and is acquit of that confusion which greatly puzzleth my brains.

SIMP. I believe verily, *Sagredus*, that you are put to a stand; and I believe that I know also the cause of your confusion, which, if I mistake not, riseth from your understanding part of those particulars but even now alledged by *Salviatus*, and but a part. It is true likewise that I find my self free from the like confusion; but not for that cause as you think, to wit, because I apprehend the whole, nay it happens upon the quite contrary account; namely, from my not comprehending any thing; and confusion is in the plurality of things, and not in nothing.

SAGR. You see *Salviatus*, how a few checks given to *Simplicius* in the dayes preceding, have rendered him gentle, and brought him from the capriol to the amble. But I beseech you without farther delay, put us both out of suspence.

SALV. I will endeavour it to the utmost of my harsh way of expressing my self, the obtuseness of which, the acuteness of your wit shall supply. The accidents of which we are to enquire the causes are two: The first respecteth the varieties that happen in the ebbings and flowings in the Monethly Period; and the other relateth to the Annual. We will first speak of the Monethly; and then treat of the Annual; and it is convenient that we resolve them all according to the Fundamentals and Hypothesis already laid down, without introducing any novelty either in Astronomy, or in the Universe; in favour of the ebbings and flowings; therefore let us demonstrate that of all the several accidents in them observed, the causes reside in the things already known; and received for true and undoubted. I say therefore, that it is a truly natural, yea necessary thing, that one and the same moveable made to move round by the same moving virtue in a longer time, do make its course by a greater circle, rather than by a lesser; and this is a truth received by all; and confirmed by all experiments, of which we will produce a few. In the wheel-clocks, and particularly in the great ones, to moderate

The true Hypothesis may dispatch its revolutions in a shorter time, in lesser circles than in greater; the which is proved by two examples.

The first example.

derate the time, the Artificers that make them accomodate a certain voluble staffe horizontally, and at each end of it they fasten two Weights of Lead; and when the time goeth too slow, by the onely removing those Leads a little nearer to the centre of the staffe, they render its vibrations more frequent; and on the contrary to retard it, it is but drawing those Weights more towards the ends; for so the vibrations are made more seldome, and consequently the intervals of the hours are prolonged.

Here the moving virtue is the same, namely the counterpoise, the moveables are those same Weights of lead, and their vibrations are more frequent when they are nearer to the centre, that is, when they move by lesser circles. Hanging equal Weights at unequal cords, and being removed from their perpendicularity, letting them go, we shall see those that are pendent at the shorter cords, to make their vibrations under shorter times, as those that move by lesser circles. Again, let such a kind of Weight be fastened to a cord, which cord let play upon a staple fastened in the Seeling, and do you hold the other end of the cord in your hand, and having given the motion to the pendent Weight, whilst it is making its vibrations, pull the end of the cord that you hold in your hand, so that the Weight may rise higher and higher: In its rising you shall see the frequency of its vibrations encrease, in regard that they are made successively by lesser and lesser circles. And here I desire you to take notice of two particulars worthy to be observed. One is that the vibrations of one of those plummets are made with such a necessity under such determinate times, that it is altogether impossible to cause them to be made under other times, unless it be by prolonging, or abbreviating the cord; of which you may also at this very instant ascertain your selves by experience, tying a stone to a pack-thread, and holding the other end in your hand, trying whether you can ever by any artifice be able to swing it this way and that way in other than one determinate time, unless by lengthening or shortening the string, which you will find to be absolutely impossible. The other particular truly admirable is, that the self same *pendulum* makes its vibrations with one and the same frequency, or very little, and as it were insensibly different, whether they be made by very great, or very small arches of the self-same circumference. I mean that whether we remove the *pendulum* from perpendicularity one, two, or three degrees onely, or whether we remove it 70. 80. nay to an entire quadrant, it being let go, will in the one case and in the other make its vibrations with the same frequency, as well the former where it is to move by an arch of but four or six degrees, as the second, where it is to passe arches of 160. or more

F f f 2

The second example.

Two particular notable accidents in the penduli and their vibrations.

Admirable Problems of moveables descending by the Quadrant of a Circle, and of those descending by all the cords of the whole Circle.

degrees. Which may the better be seen, by hanging two weights at two strings of equal length, and then removing them from perpendicularity, one a little way, and the other very far; the which being set at liberty, will go & return under the same times, the one by arches very small, & the other by very great ones, from whence followeth the conclusion of an admirable Problem, which is, That a Quadrant of a Circle being given (take a little diagram of the same, [in Fig. 3.]) as for instance: A B erect to the Horizon, so as that it rest upon the plain touching in the point B. and an Arch being made with a Hoop well plained and smoothed in the concave part, bending it according to the curvity of the Circumference A D B. So that a Bullet very round and smooth may freely run to and again within it (the rim of a Sieve is very proper for the experiment) I say, that the Bullet being put in any what ever place, neer or far from the lowest term B. As for instance, putting it in the point C, or here in D, or in E; and then let go, it will in equal times, or insensibly different arrive at the term B, departing from C, or from D, or from E, or from whatever other place; an accident truly wonderfull. We may add another accident no less strange than this, which is, That moreover by all the cords drawn from the point B to the points C, D, E; and to any other whatsoever, taken not onely in the Quadrant B A, but in all the whole circumference of the Circle the said moveable shall descend in times absolutely equal; inasmuch that it shall be no longer in descending by the whole Diameter erect perpendicularly upon the point B, then it shall in descending by B. C. although it do sublend but one sole degree, or a lesser Arch. Let us add the other wonder, which is, That the motions of the falling bodies made by the Arches of the Quadrant A B; are made in shorter times than those that are made by the cords of those same Arches; so that the swiftest motion, and made by a moveable in the shortest time, to arrive from the point A, to the term B, shall be that which is made, not by the right line A, B, (although it be the shortest of all those that can be drawn between the points A. B.) but by the circumference A D B. And any point being taken in the said Arch; as for example: The point D. and two cords drawn A D, and D. B. the moveable departing from the point A, shall in a less time come to B, moving by the two cords A D and D B. than by the sole cord A, B. But the shortest of all the times shall be that of the fall by the Arch A D B. And the self same accidents are to be understood of all the other lesser Arches taken from the lowermost term B. upwards.

SAGR. No more, no more; for you so confound and fill me with Wonders, and distract my thoughts so many several wayes, that

that I fear I shall have but a small part of it left free and disengaged, to apply to the principal matter that is treated of, and which of it self is but even too obscure and intricate: So that I intreat you to vouchsafe me, having once dispatcht the business of the ebbings and flowings, to do this honour to my house (and yours) some other dayes, and to discourse upon the so many other Problems that we have left in suspence; and which perhaps are no less curious and admirable, than this that hath been discussed these dayes past, and that now ought to draw to a conclusion.

SALV. I shall be ready to serve you, but we must make more than one or two Sessions; if besides the other questions reserved to be handled apart, we would discuss those many that pertain to the local motion, as well of natural moveables, as of the rejected: an Argument largely treated of by our *Lyncean Accademick*. But turning to our first purpose, where we were about to declare, That the bodies moving circularly by a movent virtue, which continually remaineth the same, the times of the circulations were prefixt and determined, and impossible to be made longer or shorter, having given examples, and produced experiments thereof, sensible, and feasible, we may confirm the same truth by the experiences of the Celestial motions of the Planets; in which we see the same rule observed; for those that move by greater Circles, confirm longer times in passing them. A most pertinent observation of this we have from the *Medicean Planets*, which in short times make their revolutions about *Jupiter*: Insomuch that it is not to be questioned, nay we may hold it for sure and certain, that if for example, the Moon continuing to be moved by the same movent faculty, should retire by little and little in lesser Circles, it would acquire a power of abbreviating the times of its Periods, according to that *Pendulum*, of which in the course of its vibrations, we by degrees shortned the cord, that is contracted the Semidiameter of the circumferences by it passed. Know now that this that I have alledged an example of it in the Moon, is seen and verified essentially in fact. Let us call to mind, that it hath been already concluded by us, together with *Copernicus*, That it is not possible to separate the Moon from the Earth, about which it without dispute revolveth in a Moneth: Let us remember also that the Terrestrial Globe, accompanied alwayes by the Moon, goeth along the circumference of the Grand Orb about the Sun in a year, in which time the Moon revolveth about the Earth almost thirteen times; from which revolution it followeth, that the said Moon sometimes is found near the Sun; that is, when it is between the Sun and the Earth, and sometimes much more remote, that is, when the Earth is situate between the

The Earth's annual motion by the Ecliptick, unequal by means of the Moon's motion,

the Moon and Sun ; neer, in a word, at the time of its conjunction and change ; remote, in its Full and Opposition ; and the greatest vicinity differ the quantity of the Diameter of the Lunar Orb. Now if it be true that the virtue which moveth the Earth and Moon, about the Sun, be alwayes maintained in the same vigour ; and if it be true that the same moveable moved by the same virtue, but in circles unequal, do in shorter times passe like arches of lesser circles, it must needs be granted, that the Moon when it is at a lesse distance from the Sun, that is in the time of conjunction, passeth greater arches of the Grand Orb, than when it is at a greater distance, that is in its Opppition and Full. And this Lunar inequality must of necessity be imparted to the Earth also; for if we shall suppose a right line produced from the centre of the Sun by the centre of the Terrestrial Globe, and prolonged as far as the Orb of the Moon, this shall be the semidiameter of the Grand Orb, in which the Earth, in case it were alone, would move uniformly, but if in the same semidiameter we should place another body to be carried about, placing it one while between the Earth and Sun, and another while beyond the Earth, at a greater distance from the Sun, it is necessary, that in this second case the motion common to both, according to the circumference of the great Orb by means of the distance of the Moon, do prove a little slower than in the other case, when the Moon is between the Earth and Sun, that is at a lesser distance. So that in this businesse the very same happeneth that befals in the time of the clock ; that lead which is placed one while farther from the centre, to make the vibrations of the staffe or ballance lesse frequent, and another while nearer, to make them thicker, representing the Moon. Hence it may be manifest, that the annual motion of the Earth in the Grand Orb, and under the Ecliptick, is not uniform, and that its irregularity proceedeth from the Moon, and hath its Monethly Periods and Returns. And because it hath been concluded, that the Monethly and Annual Periodick alterations of the ebbings and flowings, cannot be deduced from any other cause than from the altered proportion between the annual motion and the additions and substracons of the diurnal conversion ; and that those alterations might be made two wayes, that is by altering the annual motion, keeping the quantity of the additions unaltered, or by changing of the bignesse of these, reteining the uniformity of annual motion. We have already found the first of these, depending on the irregularity of the annual motion occasioned by the Moon, and which hath its Monethly Periods. It is therefore necessary, that upon that account the ebbings and flowings have a Monethly Period in which they do grow greater

greater and lesser. Now you see that the cause of the Monethly Period resideth in the annual motion; and withal you see how much the Moon is concerned in this business, and how it is therein interrupted apart, without having any thing to do with either, with Seas or Waters.

SAGR. If one that never had seen any kinde of Stairs or Ladder, were shewed a very high Tower, and asked if ever he hoped to climb to the top of it, I verily believe that he would answer he did not, not conceiving how one should come thither any way except by flying; but shewing him a stone of but a foot high, and asking him whether he thought he could get to the top of that, I am certain that he would answer he could; and farther, that he would not deny, but that it was not onely one, but ten, twenty, and an hundred times easier to climb that: But now if he should be shewed the Stairs, by means whereof, with the facility by him granted, it is possible to get thither, whither he a little before had affirmed it was impossible to ascend, I do think that laughing at himself he would confesse his dulness of apprehension. Thus, *Salvatus*, have you step by step so gently lead me, that, not without wonder, I finde that I am got with small pains to that height which I despaired of arriving at. 'Tis true; that the Staircase having been dark, I did not perceive that I was got nearer to, or arrived at the top, till that coming into the open Air I discovered a great Sea, and spacious Country: And as in ascending one step, there is no labour; so each of your propositions by it self seemed to me so plain, that thinking I heard but little or nothing that was new unto me, I conceived that my benefit thereby had been little or none at all: Whereupon I was the more amazed at the unexpected exit of this discourse, that hath guided me to the knowledge of a thing which I held impossible to be demonstrated. One doubt onely remains, from which I desire to be freed, and this it is; Whether that if the motion of the Earth together with that of the Moon under the Zodiack are irregular motions, those irregularities ought to have been observed and taken notice of by *Astronomers*, which I do not know that they are: Therefore I pray you, who are better acquainted with these things than I, to free me from this doubt; and tell me how the case stands.

SALV. You ask a rational question, and answering to the objection, I say; That although *Astronomy* in the courses of many ages hath made a great progress in discovering the constitution and motions of the Celestial bodies, yet is it not hitherto arrived at that height, but that very many things remain undecided, and haply many others also undiscovered. It is to be supposed that the first observers of Heaven knew no more but one motion common to

Many things
may remain as yet
unobserved in *Astronomy*.

*Saturn for its
slowness, and Mer-
cury for its rare-
ness, of appearing
were amongst those
that were last ob-
served.*

*Particular stru-
ctures of the Orbs
of the Planets not
yet well resolved.*

*The Sun pass-
eth one half of the
Zodiack nine days
sooner than the
other.*

*The Moons mo-
tion principally
sought in the ac-
count of Eclipses.*

to all the Stars, as is this diurnal one: yet I believe that in few dayes they perceived that the Moon was inconstant: in keeping company with the other Stars; but yet withal, that many years past, before that they distinguished all the Planets: And in particular, I conceit that *Saturn* by its slowness, and *Mercury* by reason of its seldom appearing, were the last that were observed to be wandring and errant. It is to be thought that many more years run out before the stations and retrogradations of the three superiour Planets were known, as also their approximations and recessions from the Earth, necessary occasions of introducing the Eccentrix and Epicycles, things unknown even to *Aristotle*, for that he makes no mention thereof. *Mercury*, and *Venus*, with their admirable apparitions; how long did they keep Astronomers in suspence, before that they could resolve (not to speak of any other of their qualities) upon their situation? Inasmuch that the very order onely of the Mundane bodies, and the integral structure of the parts of the Universe by us known, hath been doubted of untill the time of *Copernicus*, who hath at last given us notice of the true constitution, and real systeme, according to which those parts are disposed; so that at length we are certain that *Mercury*, *Venus*, and the other Planets do revolve about the Sun; and that the Moon revolveth about the Earth. But how each Planet governeth it self in its particular revolution, and how precisely the structure of its Orb is framed; which is that which is vulgarly called the *Theory* of the Planets, we cannot as yet undoubtedly resolve. *Mars*, that hath so much puzzled our Modern Astronomers, is a proof of this: And to the Moon herself there have been assigned several Theories, after that the said *Copernicus* had much altered it from that of *Ptolomy*. And to descend to our particular case, that is to say, to the apparent motion of the Sun and Moon; touching the former, there hath been observed a certain great irregularity, whereby it passeth the two semicircles of the Ecliptick, divided by the points of the Equinoxes in very different times; in passing one of which, it spendeth about nine dayes more than in passing the other; a difference, as you see, very great and notable. But if in passing small arches, such for example as are the twelve Signs, he maintain a most regular motion, or else proceed with paces, one while a little more swift, and another more slow, as it is necessary that it do, in case the annual motion belong to the Sun onely in appearance, but in reality to the Earth in company with the Moon, it is what hath not hitherto been observed, nor it may be sought. Touching the Moon in the next place, whose restitutions have been principally lookt into an account of the Eclipses, for which it is sufficient to have an exact knowledge of its motion about the Earth,

it

it hath not been likewise with a perfect curiosity inquired, what its course is thorow the particular arches of the Zodiack. That therefore the Earth and Moon in running through the Zodiack, that is round the Grand Orb, do somewhat accelerate at the Moons change, and retard at its full, ought not to be doubted; for that the said difference is not manifest, which cometh to be unobserved upon two accounts; First, Because it hath not been lookt for. Secondly, Because that its possible it may not be very great. Nor is there any need that it should be great, for the producing the effect that we see in the alteration of the greatness of ebbings and flowings. For not onely those alterations, but the Tides themselves are but small matters in respect of the grandure of the subjects on which they work; albeit that to us, and to our littleness they seem great. For the addition or subduction of one degree of velocity where there are naturally 700, or 1000, can be called no great alteration, either in that which conferreth it, or in that Which receiveth it: the Water of our Mediterrane carried about by the diurnal revolution, maketh about 700 miles an hour, (which is the motion common to the Earth and to it, and therefore not perceptible to us) & that which we sensibly discern to be made in the streams or currents, is not at the rate of full one mile an hour, (I speak of the main Seas, and not of the Straights) and this is that which altereth the first, naturall, and grand motion; and this motion is very great in respect of us, and of Ships: for a Vessel that in a standing Water by the help of Oares can make *v. g.* three miles an hour; in that same current will row twice as far with the stream as against it: A notable difference in the motion of the Boat, though but very small in the motion of the Sea, which is altered but its seven hundredth part. The like I say of its rising, and falling one, two, or three feet; and scarcely four or five in the utmost bounds of a streight, two thousand, or more miles long, and where there are depths of hundreds of feet; this alteration is much less than if in one of the Boats that bring us fresh Water, the said Water upon the arrest of the Boat should rise at the Prow the thickness of a leaf. I conclude therefore that very small alterations in respect of the immense greatness, and extraordinary velocity of the Seas, is sufficient to make therein great mutations in relation to our smallness, and to our accidents.

S A G R. I am fully satisfied as to this particular; it remains to declare unto us how those additions and substractions derived from the diurnal *Vertigo* are made one while greater, and another while lesser; from which alterations you hinted that the annual period of the augmentations and diminutions of the ebbings and flowings did depend.

G g g

S A L V.

Ebbings and flowings are petty things in comparison of the vastness of Seas, and of the velocity of the motion of the Terrestrial Globe.

*The causes of
the inequality of
the additions and
subtractions of the
diurnal conversion
from the annual
motion.*

SALV. I will use my utmost endeavours to render my self intelligible, but the difficulty of the accident it self, and the great attention of mind requisite for the comprehending of it, constrains me to be obscure. The unequalities of the additions and subtractions, that the diurnal motion maketh to or from the annual dependeth upon the inclination of the Axis of the diurnal motion upon the plane of the Grand Orb, or, if you please, of the Ecliptick; by means of which inclination the Equinoctial intersecteth the said Ecliptick; remaining inclined and oblique upon the same according to the said inclination of Axis. And the quantity of the additions importeth as much as the whole diameter of the said Equinoctial, the Earths centre being at the same time in the Solstitial points; but being out of them it importeth lesse and lesse, according as the said centre successively approacheth to the points of the Equinoxes, where those additions are lesse than in any other places. This is the whole businesse, but wrapt up in the obscurity that you see.

SAGR. Rather in that which I do not see; for hitherto I comprehend nothing at all.

SALV. I have already foretold it. Neverthelesse we will try whether by drawing a Diagram thereof, we can give some small light to the same; though indeed it might better be set forth by solid bodies than by bare Schemes; yet we will help our selves with Perspective and fore-shortning. Let us draw therefore, as before, the circumference of the Grand Orb, [as in Fig. 4.] in which the point A is understood to be one of the Solstitials, and the diameter AP the common Section of the Solstitial Colure, and of the plane of the Grand Orb or Ecliptick; and in that same point A let us suppose the centre of the Terrestrial Globe to be placed, the Axis of which CAB, inclined upon the Plane of the Grand Orb, falleth on the plane of the said Colure that passeth thorow both the Axis of the Equinoctial, and of the Ecliptick. And for to prevent confusion, let us only draw the Equinoctial circle, marking it with these characters D G E F, the common section of which, with the plane of the grand Orb, let be the line D E, so that half of the said Equinoctial D F E will remain inclined below the plane of the Grand Orb, and the other half D G E elevated above. Let now the Revolution of the said Equinoctial be made, according to the order of the points D G E F, and the motion of the centre from A towards E. And because the centre of the Earth being in A, the Axis C B (which is erect upon the diameter of the Equinoctial D E) falleth, as hath been said, in the Solstitial Colure, the common Section of which and of the Grand Orb, is the diameter P A, the said line P A shall be

be perpendicular to the same D E, by reason that the Colure is erect upon the grand Orb; and therefore the said D E, shall be the Tangent of the grand Orb in the point A. So that in this Position the motion of the Centre by the arch A E; that is, of one degree every day differeth very little; yea, is as if it were made by the Tangent D A E. And because by means of the diurnal motion the point D, carried about by G, unto E, encreaseth the motion of the Centre moved almost in the same line D E, as much as the whole diameter D E amounts unto; and on the other side diminisheth as much, moving about the other semicircle E F D. The additions and subductions in this place therefore, that is in the time of the solstice, shall be measured by the whole diameter D E.

Let us in the next place enquire, Whether they be of the same bigness in the times of the Equinoxes; and transporting the Centre of the Earth to the point I, distant a Quadrant of a Circle from the point A. Let us suppose the said Equinoctial to be G E F D, its common section with the grand Orb D E, the Axis with the same inclination C B; but the Tangent of the grand Orb in the point I shall be no longer D E, but another which shall cut that at right Angles; and let it be this marked H I L, according to which the motion of the Centre I, shall make its progress, proceeding along the circumference of this grand Orb. Now in this state the Additions and Subductions are no longer measured by the diameter D E, as before was done; because that diameter not distending it self according to the line of the annual motion H L, rather cutting it at right angles, those terms D E, do neither add nor substract any thing; but the Additions and Subductions are to be taken from that diameter that falleth in the plane that is erect upon the plane of the grand Orb, and that intersects it according to the line H L; which diameter in this case shall be this G F and the Adjective, if I may so say, shall be that made by the point G, about the semicircle G E F, and the Ablative shall be the rest made by the other semicircle F D G. Now this diameter, as not being in the same line H L of the annual motion, but rather cutting it, as we see in the point I, the term G being elevated above, and E depressed below the plane of the grand Orb, doth not determine the Additions and Subductions according to its whole length, but the quantity of those first ought to be taken from the part of the line H L, that is intercepted between the perpendiculars drawn upon it from the terms G F; namely, these two G S, and F V: So that the measure of the additions is the line S V lesser then G F, or then D E; which was the measure of the additions in the Solstice A. And so successively, according as the centre of the Earth shall be constituted

G g g 2

stituted in other points of the Quadrant A I, drawing the Tangents in the said points, and the perpendiculars upon the same falling from the terms of the diameters of the Equinoctial drawn from the erect planes by the said Tangents to the plane of the grand Orb; the parts of the said Tangents (which shall continually be lesser towards the Equinoctials, and greater towards the Solstices) shall give us the quantities of the additions and subtractions. How much in the next place the least additions differ from the greatest, is easie to be known, because there is the same difference betwixt them, as between the whole Axis or Diameter of the Sphere, and the part thereof that lyeth between the Polar-Circles; the which is less than the whole diameter by very near a twelfth part, supposing yet that we speak of the additions and subtractions made in the Equinoctial; but in the other Parallels they are lesser, according as their diameters do diminish.

This is all that I have to say upon this Argument, and all perhaps that can fall under the comprehension of our knowledge, which, as you well know, may not entertain any conclusions, save onely those that are firm and constant, such as are the three kinds of Periods of the ebbings and flowings; for that they depend on causes that are invariable, simple, and eternal. But because that secondary and particular causes, able to make many alterations, intermix with these that are the primary and universal; and these secondary causes being part of them inconstant, and not to be observed; as for example, The alteration of Winds, and part (though terminate and fixed) unobserved for their multiplicity, as are the lengths of the Straights, their various inclinations towards this or that part, the so many and so different depths of the Waters, who shall be able, unless after very long observations, and very certain relations, to frame so expeditious Histories thereof, as that they may serve for Hypotheses, and certain suppositions to such as will by their combinations give adequate reasons of all the appearances, and as I may say, Anomalie, and particular irregularities that may be discovered in the motions of the Waters? I will content my self with advertising you, that the accidental causes are in nature, and are able to produce many alterations; for the more minute observations, I remit them to be made by those that frequent several Seas: and onely by way of a conclusion to this our conference, I will propose to be considered, how that the precise times of the fluxes and refluxes do not onely happen to be altered by the length of Straights, and by the difference of depths; but I believe that a notable alteration may also proceed from the comparing together of sundry parts of Sea, different in greatness; and in position, or, if you will, inclination; which difference happeneth exactly here in the *Adriatick* Gulph,

Gulph, lesse by far than the rest of the Mediterrane, and placed in so different an inclination, that whereas that hath its bounds that incloseth it on the Eastern part, as are the Coasts of Syria, this is shut up in its more Westerly part: and because the ebbings and flowings are much greater towards the extremities, yea, because the Seas risings and fallings are there onely greatest, it may probably happen that the times of Flood at Venice may be the time of low Water in the other Sea, which, as being much greater, and distended more directly from West to East, cometh in a certain sort to have dominion over the Adriatick: and therefore it would be no wonder, in case the effects depending on the primary causes, should not hold true in the times that they ought, and that correspond to the periods in the Adriatick, as it doth in the rest of the Mediterrane. But these Particularities require long Observations, which I neither have made as yet, nor shall I ever be able to make the same for the future.

SAGR. You have, in my opinion, done enough in opening us the way to so lofty a speculation, of which, if you had given us no more than that first general Proposition that seemeth to me to admit of no reply, where you declare very rationally, that the Vessels containing the Sea-waters continuing stedfast, it would be impossible, according to the common course of Nature, that those motions should follow in them which we see do follow; and that, on the other side, granting the motions ascribed, for other respects, by Copernicus to the Terrestrial Globe, these same alterations ought to ensue in the Seas, if I say you had told us no more, this alone in my judgment, so far exceeds the vanities introduced by so many others; that my meer looking on them makes me nauseate them; and I very much admire, that among men of sublime wit, of which nevertheless there are not a few, not one hath ever considered the incompatibility that is between the reciprocal motion of the Water contained, and the immobility of the Vessel containing, which contradiction seemeth to me now so manifest.

SALV. It is more to be admired, that it having come into the thoughts of some to refer the cause of the Tide to the motion of the Earth, therein shewing a more than common apprehension, they should, in afterwards driving home the motion close with no tide; and all, because they did not see that one simple and uniform motion, as *v. gr.* the sole diurnal motion of the Terrestrial Globe, doth not suffice, but that there is required an uneven motion, one while accelerated, and another while retarded: for when the motion of the Vessels are uniforme, the waters contained will habituate themselves thereto, without ever making any alteration. To say also (as it is related of an ancient

One single motion of the terrestrial Globe sufficeth not to produce the Ebbing & Flowing

Mathe-

*The opinion of
Seleucus the Ma-
thematician censu-
red.*

*Kepler is with
respect blamed.*

Mathematician) that the motion of the Earth meeting with the motion of the Lunar Orb, the concurrence of them occasioneth the Ebbing and Flowing, is an absolute vanity, not onely because it is not exprest, nor seen how it should so happen, but the falsity is obvious, for that the Revolution of the Earth is not contrary to the motion of the Moon, but is towards the same way. So that all that hath been hitherto said, and imagined by others, is, in my judgment, altogether invalid. But amongst all the famous men that have philosophated upon this admirable effect of Nature, I more wonder at *Kepler* than any of the rest, who being of a free and piercing wit, and having the motion ascribed to the Earth, before him, hath for all that given his ear and assent to the Moons predominancy over the Water, and to occult properties, and such like trifles.

SAGR. I am of opinion, that to these more speculative persons the same happened, that at present befalls me, namely, the not understanding the intricate commixtion of the three Periods Annual, Monethly, and Diurnal; And how their causes should seem to depend on the Sun, and on the Moon, without the Suns or Moons having any thing to do with the Water; a business, for the full understanding of which I stand in need of a little longer time to consider thereof, which the novelty and difficulty of it hath hitherto hindered me from doing: but I despair not, but that when I return in my solitude and silence to ruminate that which remaineth in my fancy, not very well digested, I shall make it my own. We have now, from these four dayes Discourse, great attestations, in favour of the *Copernican* Systeme, amongst which these three taken: the first, from the Stations and Retrogradations of the Planets, and from their approaches, and recessions from the Earth; the second, from the Suns revolving in it self, and from what is observed in its spots; the third, from the Ebbing and Flowing of the Sea do shew very rational and concluding.

*Sig. Cesare Mar-
silius observeth the
Meridian, to be
moveable.*

SALV. To which also haply, in short, one might adde a fourth, and peradventure a fifth; a fourth, I say, taken from the fixed stars, seeing that in them, upon exact observations, those minute mutations appear, that *Copernicus* thought to have been insensible. There starts up, at this instant, a fifth novelty, from which one may argue mobility in the Terrestrial Globe, by means of that which the most Illustrious *Signore Cesare*, of the noble Family of the *Marsili* of *Bologna*, and a *Lyncean* Academick, discovereth with much ingenuity, who in a very learned Tract of his, sheweth very particularly how that he had observed a continual mutation, though very slow in the Meridian line, of which Treatise, at length, with amazement, perused by me,

I

I hope he will communicate Copies to all those that are Students of Natures Wonders.

SAGR. This is not the first time that I have heard speak of the exquisite Learning of this Gentleman, and of his shewing himself a zealous Patron of all the Learned, and if this, or any other of his Works shall come to appear in publique, we may be aforehand assured, that they will be received, as things of great value.

SALV. Now because it is time to put an end to our Discourses, it remaineth, that I intreat you, that if, at more leasure going over the things again that have been alledged you meet with any doubts, or scruples not well resolved, you will excuse my oversight, as well for the novelty of the Notion, as for the weaknesse of my wit, as also for the grandure of the Subject, as also finally, because I do not, nor have pretended to that assent from others, which I my self do not give to this conceit, which I could very easily grant to be a *Chymera*, and a meer paradox; and you *Sagredus*, although in the Discourses past you have many times, with great applause, declared, that you were pleased with some of my conjectures, yet do I believe, that that was in part more occasioned by the novelty than by the certainty of them, but much more by your courtesie, which did think and desire, by its assent, to procure me that content which we naturally use to take in the approbation and applause of our own matters: and as your civility hath obliged me to you; so am I also pleased with the ingenuity of *Simplicius*. Nay, his constancy in maintaining the Doctrine of his Master, with so much strength & undauntedness, hath made me much to love him. And as I am to give you thanks, *Sagredus*, for your courteous affection; so of *Simplicius*, I ask pardon, if I have sometimes moved him with my too bold and resolute speaking: and let him be assured that I have not done the same out of any inducement of sinister affection, but onely to give him occasion to set before us more lofty fancies that might make me the more knowing.

SIMP. There is no reason why you should make all these excuses, that are needlesse, and especially to me, that being accustomed to be at Conferences and publique Disputes, have an hundred times seen the Disputants not onely to grow hot and angry at one another, but likewise to break forth into injurious words, and sometimes to come very neer to blows. As for the past Discourses, and particulatly in this last, of the reason of the Ebbing and Flowing of the Sea, I do not, to speak the truth, very well apprehend the same, but by that slight *Idea*, what ever it be, that I have formed thereof to my self, I confesse that your conceit seemeth to me far more ingenious than any of all those

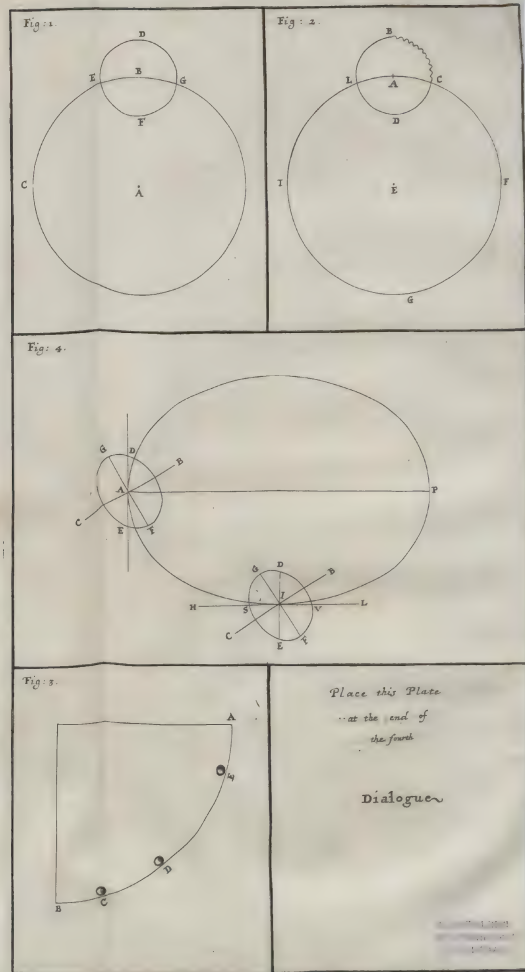
those that I ever heard besides, but yet neverthelesse I esteem it not true and concluding: but keeping alwayes before the eyes of my mind a solid Doctrine that I have learn't from a most learned and ingenuous person, and with which it is necessary to sit down; I know that both you being asked, Whether God, by his infinite Power and Wisdome might confer upon the Element of Water the reciprocal motion which we observe in the same in any other way, than by making the containing Vessel to move; I know, I say, that you will answer, that he might, and knew how to have done the same many wayes, and those unimaginable to our shallow understanding: upon which I forthwith conclude, that this being granted, it would be an extravagant boldnesse for any one to goe about to limit and confine the Divine Power and Wisdome to some one particular conjecture of his own.

SALV. This of yours is admirable, and truly Angelical Doctrine, to which very exactly that other accords, in like manner divine, which whilst it giveth us leave to dispute, touching the constitution of the World, addeth withall (perhaps to the end, that the exercise of the minds of men might neither be discouraged, nor made bold) that we cannot find out the works made by his hands. Let therefore the Disquisition permitted and ordained us by God, assist us in the knowing, and so much more admiring his greatnesse, by how much lesse we finde our selves too dull to penetrate the profound Abysses of his infinite Wisdome.

SAGR. And this may serve for a final close of our four dayes Disputations, after which, if it seem good to *Salviatus*, to take some time to rest himself, our curiosity must, of necessity, grant him the same, yet upon condition, that when it is lesse incommodious for him, he will return and satisfie my desire in particular concerning the Problemes that remain to be discusst, and that I have set down to be propounded at one or two other Conferences, according to our agreement: and above all, I shall very impatiently wait to hear the Elements of the new Science of our *Academick* about the natural and violent local Motions. And in the mean time, we may, according to our custome, spend an hour in taking the Air in the *Gondola* that waiteth for us.

FINIS.

it
is
ft
o
y
it
in
I
w
o
e
le
ne
of
o
er
he
d,
u
de
pr
ne
es
if
es
ke
nt
o
lar
t
I
n
ry
ur
nd
an



Place this Plate
at the end of
the fourth
Dialogue



BIBLIOTHECA
UNIVERSITATIS
HAUNIENSIS

THE
Ancient and Modern
DOCTRINE
OF
Holy Fathers,
AND
Iudicious Divines,

CONCERNING

The rash citation of the Testimony of SACRED
SCRIPTURE, in Conclusions meerly Natural, and
that may be proved by Sensible Experiments, and
Necessary Demonstrations.

Written, some years since, to Gratifie The most SERENE
CHRISTINA LOTHARINGA, Arch-
Dutcheſs of TUSCANY;

By GALILÆO GALILÆI, A Gentleman of
Florence, and Chief Philoſopher and Mathematician to
His moſt Serene Highneſs the Grand D U K E.

And now rendred into Engliſh from the Italian,
B Y

THOMAS SALUSBURY.

*Naturam Rerum invenire, difficile; & ubi inveneris, indicare
in vulgus, neſas. Plato.*

LONDON,
Printed by WILLIAM LEYBOURN, 1661.
Hhh

(a) Nunc autem, servata semper moderatione pia gravitatis, nihil credere de re obscura temere debemus, ne forte, quod postea veritas patefecerit, quamvis Libris Sanctis, sive Testamenti Veteris, sive Novi, nullo modo esse posse adversum, tamen propter a morem nostri erroris, oderimus.

Lib. 2. Genesi ad Literam in fine.

are obscure and hard to be understood by the meer help of ratiocination; where treating (as we) of a certain natural conclusion concerning Celestial Bodies, he thus writes: (a) *But now having evermore a respect to the moderation of pious Gravity, we ought to believe nothing unadvisedly in a doubtful point; lest we conceive a prejudice against that, in favour to our Error, which Truth hereafter may discover to be no wise contrary to the Sacred Books either of the Old, or New Testament.*

It hath since come to pass, that Time hath by degrees discovered to every one the truths before by me indicated: and together with the truth of the fact, a discovery hath been made of the difference of humours between those who simply and without passion did refuse to admit such like *Phænomena* for true, and those who to their incredulity had added some discomposed affection: For as those who were better grounded in the Science of Astronomy, and Natural Philosophy, became satisfied upon my first intimation of the news; so all those who stood not in the Negative, or in doubt for any other reason, but because it was an unlookt-for Novelty, and because they had not an occasion of seeing a sensible experiment thereof, did by degrees come to satisfy themselves. But those, who besides the love they bore to their first Error, have I know not what imaginary interests to render them disaffected; not so much towards the things, as towards the Author of them, not being able any longer to deny them, conceal themselves under an obstinate silence; and being exasperated more than ever by that whereby those others were satisfied and convinced, they divert their thoughts to other projects, and seek to prejudice me some other wayes: of whom I profess that I would make no more account than I have done of those who heretofore have contradicted me (at whom I alwaies laugh, as being assured of the issue that the business is to have) but that I see that those new Calumnies and Persecutions do not determine in our greater or lesser Learning (in which I will scarce pretend to any thing) but extend so far as to attempt to asperse me with Crimes which ought to be, and are more abhorred by me than Death it self. Not ought I to content my self that they are known to be unjust by those onely who know me and them, but by all men whatsoever. They persisting therefore in their first Resolution, Of ruining me and whatsoever is mine; by all imaginable waies; and knowing how that in my Studies of Astronomy and Philosophy hold, as to the Worlds System, That the Sun, without changing place, is situate in the Centre of the Conversion of the Celestial Orbes; and that the Earth, convertible about its own Axis, moveth it self about the Sun: And moreover understanding, that I proceed to maintain this Position

sition, not onely by refuting the Reasons of *Ptolomy* and *Aristotle*, but by producing many on the contrary; and in particular, some Physical pertaining to Natural Effects, the causes of which perhaps can be by no other way assigned; and others Astronomical depending upon many circumstances and encounters of new Discoveries in Heaven, which manifestly confute the *Ptolomaick* Systeme, and admirably agree with and confirm this other Hypothesis: and possibly being ashamed to see the known truth of other Positions by me asserted, different from those that have been commonly received; and therefore distrusting their defence so long as they should continue in the Field of Philosophy: for these respects, I say, they have resolved to try whether they could make a Shield for the fallacies of their Arguments of the Mantle of a feigned Religion, and of the Authority of the Sacred Scriptures, applyed by them with little judgment to the confutation of such Reasons of mine as they had neither understood, nor so much as heard.

And first, they have indeavoured, as much as in them lay, to divulge an opinion thorow the Universe, that those Propositions are contrary to the Holy Letters, and consequently Damnable and Heretical: And thereupon perceiving, that for the most part, the inclination of Mans Nature is more prone to imbrace those enterprizes, whereby his Neighbour may, although unjustly, be oppressed, than those from whence he may receive just encouragement; it was no hard matter to find those Complices, who for such (that is, for Damnable and Heretical) did from their Pulpits with unwonted confidence preach it, with but an unmerciful and less considerate injury, not only to this Doctrine, and to its followers, but to all Mathematicks and Mathematicians together. Hereupon assuming greater confidence, and vainly hoping that that Seed which first took root in their unsound mindes, might spread its branches, and ascend towards Heaven, they went scattering rumours up and down among the People, That it would ere long be condemned by Supreme Authority: and knowing that such a Censure would supplant not onely these two Conclusions of the *VVorlds* Systeme, but would make all other Astronomical and Physical Observations that have correspondence and necessary connection therewith to become damnable, to facilitate the business they seek all they can to make this opinion (at least among the vulgar) to seem new, and peculiar to my self, not owning to know that *Nicholas Copernicus* was its Authour, or rather Restorer and Confirmer: a person who was not only a Catholick, but a Priest, Canonick, and so esteemed, that there being a Dispute in the *Lateran Council*, under *Leo X.* touching the correction of the Ecclesiastick Calendar

lendar, he was sent for to Rome from the remotest parts of Germany, for to assist in this Reformation, which for that time was left imperfect, onely because as then the true measure of the Year and Lunar Moneth was not exactly known: whereupon it was given him in charge by the Bishop of *Sempronia*, at that time Super-intendent in that Affair, to search with reiterated studies and pains for greater light and certainty, touching those Cœlestial Motions. Upon which, with a Labour truly *Atlantick*, and with his admirable Wit, setting himself again to that Study, he made such a progress in these Sciences, and reduced the knowledge of the Cœlestial Motions to such exactness, that he gained the title of an Excellent *Astronomer*. And, according unto his Doctrine, not only the Calendar hath been since regulated, but the Tables of all the Motions of the Planets have also been calculated: and having reduced the said Doctrine into six Books, he published them to the World at the instance of the Cardinal of *Capua*, and of the Bishop of *Culma*. And in regard that he had re-assumed this so laborious an enterprize by the order of The Pope; he dedicated his Book *De Revolutionibus Cœlestibus* to His Successour, namely *Paul III.* which, being then also Printed, hath been received by The Holy Church, and read and studied by all the World, without any the least umbrage of scruple that hath ever been conceived at his Doctrine; The which, whilst it is now proved by manifest Experiments and necessary Demonstrations to have been well grounded, there want not persons that, though they never saw that same Book intercept the reward of those many Labours to its Authour, by causing him to be censured and pronounced an Heretick; and this, only to satisfie a particular displeasure conceived, without any cause, against another man, that hath no other interest in *Copernicus*, but only as he is an approver of his Doctrine.

Now in regard of these false aspersions, which they so unjustly seek to throw upon me, I have thought it necessary for my justification before the World (of whose judgment in matters of Religion and Reputation I ought to make great esteem) to discourse concerning those Particulars, which these men produce to scandalize and subvert this Opinion; and in a word, to condemn it, not only as false, but also as Heretical; continually making an Hipocritical Zeal for Religion their Shield; going about moreover to interest the Sacred Scriptures in the Dispute, and to make them in a certain sense Ministers of their deceitful purposes: and farthermore desiring, if I mistake not, contrary to the intention of them, and of the Holy Fathers to extend (that I may not say abuse) their Authority, so as that even in Conclusions meerly Natural, and not *de Fide*, they would have us altogether leave

leave Sense and Demonstrative Reasons, for some place of Scripture which sometimes under the apparent words may contain a different sense. Now I hope to shew with how much greater Piety and Religious Zeal I proceed, than they do, in that I propose not, that the Book of *Copernicus* is not to be condemned, but that it is not to be condemned, as they would have it; without understanding it, hearing it, or so much as seeing it; and especially he being an Author that never treateth of matters of Religion or Faith; nor by Reasons any way depending on the Authority of Sacred Scriptures whereupon he may have erroneously interpreted them; but alwaies insists upon Natural Conclusions belonging to the Celestial Motions, handled with Astronomical and Geometrical Demonstrations. Not that he had not a respect to the places of the Sacred Leaves, but because he knew very well that his said Doctrine being demonstrated, it could not contradict the Scriptures, rightly, and according to their true meaning understood. And therefore in the end of his Epistle Dedicatory, speaking to The Pope, he saith thus: (b) If there should chance to be any *Matæologs*, who though ignorant in all the *Mathematicks*, yet pretending a skill in those Learnings, should dare, upon the authority of some place of Scripture wrested to their purpose, to condemn and censure this my Hypothesis, I value them not, but shall slight their inconsiderate Judgement. For it is not unknown, that *Lactantius* (otherwise a Famous Author, though mean Mathematician) writeth very childishly touching the Form of the Earth, when he scoffs at those who affirm the Earth to be in Form of a Globe. So that it ought not to seem strange to the Ingenious, if any such should likewise now deride us. The *Mathematicks* are written for Mathematicians; to whom (if I deceive not my self) these Labours of mine shall seem to add something, as also to the Common-weale of the Church, whose Government is now in the hands of Your Holiness.

And of this kinde do these appear to be who endeavour to perswade that *Copernicus* may be condemned before his Book is read; and to make the World believe that it is not onely lawfull but commendable so to do, produce certain Authorities of the Scripture, of Divines, and of Councils; which as they are by me had in reverence, and held of Supream Authority, inso much that I should esteem it high temerity for any one to contradict them whilst they are used according to the Institutes of Holy Church, so I believe that it is no error to speak, so long as one hath reason to suspect that a person hath a desire, for some concern of his own, to produce and alledge them, to purposes different from those that are in the most Sacred intention of The Holy Church. Therefore I not onely protest (and my sincerity shall manifest it self)

(c) Si fortasse erunt
Matæologi, qui
cum omnium Ma-
thematicum igna-
ri sint, tamen de iis
judicium assu-
munt, propter ali-
quem locum Scri-
pturæ, male ad su-
um propositum, de-
vortum, aut si fue-
rit hoc meum in-
stitutum reprehen-
dere ac insectari,
illos nihil moror,
adco ut etiam illo-
rum judicium, tan-
quam temerarium
contemnam. Non
enim obscurum est,
Lactantium, cele-
brem aliqui
Scriptorem, sed
Mathematicum
parvum, admodum
pueriliter de forma
Terra loqui, cum
deridet eos, qui
Terram, Globi for-
mam habere prodi-
derunt. Itaque non
debet mirum videri
studiosis, si qui-
tales, nos etiam ri-
debunt. Mathema-
tica Mathematicis
scribuntur; quibus
& hi nostri labo-
res, (si me non fal-
lis opinio) vide-
buntur etiam Rai-
publicæ Ecclesia-
stica conducere a-
liiquid, cuius Prin-
cipatum Tua San-
ctitas nunc tenet.

self) that I intend to submit my self freely to renounce those errors, into which, through ignorance, I may run in this Discourse of matters pertaining to Religion; but I farther declare, that I desire not in these matters to engage dispute with any one; although it should be in points that are disputable: for my end endeth onely to this, That if in these considerations, besides my own profession, amongst the errors that may be in them, there be any thing apt to give others an hint of some Notion beneficial to the Holy Church, touching the determining about the *Copernican* System, it may be taken and improved as shall seem best to my Superiours: If not, let my Book be torn and burnt; for that I do neither intend, nor pretend to gain to my self any fruit from my writings, that is not Pious and Catholick. And moreover, although that many of the things that I observe have been spoken in my own hearing, yet I shall freely admit and grant to those that spake them, that they never said them, if so they please, but confess that I might have been mistaken: And therefore what I say, let it be supposed to be spoken not by them, but by those which were of this opinion.

The motive therefore that they produce to condemn the Opinion of the Mobility of the Earth, and Stability of the Sun, is, that reading in the Sacred Leaves, in many places, that the Sun moveth, that the Earth standeth still; and the Scripture not being capable of lying, or erring, it followeth upon necessary consequence, that the Position of those is Erronious and Heretical, who maintain that the Sun of it self is immoveable, and the Earth moveable.

Touching this Reason I think it fit in the first place, to consider, That it is both piously spoken, and prudently affirmed, That the Sacred Scripture can never lye, when ever its true meaning is understood: Which I believe none will deny to be many times very abstruse, and very different from that which the bare sound of the words signifieth. Whence it cometh to pass, that if ever any one should constantly confine himself to the naked Grammatical Sence, he might, erring himself, make not only Contradictions and Propositions remote from Truth to appear in the Scriptures, but also gross Heresies and Blasphemies: For that we should be forced to assign to God feet, and hands, and eyes, yea more corporal and humane affections, as of Anger; of Repentance, of Hatred, nay, and sometimes the Forgetting of things past, and Ignorance of those to come: Which Propositions, like as (so the Holy Ghost affirmeth) they were in that manner pronounced by the Sacred Scriptures, that they might be accommodated to the Capacity of the Vulgar, who are very rude and unlearned; so likewise, for the sakes of those that deserve to be distinguished

tinguished from the Vulgar, it is necessary that grave and skilful Expositors produce the true senses of them; and shew the particular Reasons why they are dictated under such and such words. And this is a Doctrine so true and common amongst Divines, that it would be superfluous to produce any attestation thereof.

Hence methinks I may with much more reason conclude; that the same holy Writ, when ever it hath had occasion to pronounce any natural Conclusion; and especially, any of those which are more abstruse, and difficult to be understood, hath not failed to observe this Rule, that so it might not cause confusion in the mindes of those very people, and render them the more contumacious against the Doctrines that were more sublimely mysterious: For (like as we have said, and as it plainly appeareth) our of the sole respect of condescending to Popular Capacity, the Scripture hath not scrupled to shadow over most principal and fundamental Truths, attributing, even to God himself, qualities extremely remote from, and contrary unto his Essence. Who would positively affirm that the Scripture, laying aside that respect, in speaking but occasionally of the Earth, of the Water, of the Sun, or of any other Creature, hath chosen to confine it self, with all rigour, within the bare and narrow literal sense of the words? And especially, in mentioning of those Creatures, things not at all concerning the primary Institution of the same Sacred Volume, to wit, the Service of God, and the salvation of Souls, and in things infinitely beyond the apprehension of the Vulgar?

This therefore being granted, methinks that in the Discussion of Natural Problemes, we ought not to begin at the authority of places of Scripture; but at Sensible Experiments and Necessary Demonstrations: For, from the Divine Word, the Sacred Scripture and Nature did both alike proceed; the first, as the Holy Ghosts Inspiration; the second, as the most observant Executrix of Gods Commands. And moreover it being convenient in the Scriptures (by way of condescension to the understanding of all men) to speak many things different, in appearance; and so far as concerns the naked signification of the words, from absolute truth: But on the contrary, Nature being inexorable and immutable; and never passing the bounds of the Laws assigned her, as one that nothing careth whether her abstruse reasons and methods of operating be, or be not exposed to the Capacity of Men; I conceive that that, concerning Natural Effects, which either Sensible Experience sets before our eyes, or Necessary Demonstrations do prove unto us, ought not, upon any account, to be called into question, much less

Not definitus,
Deum, primò Na-
tura cognoscen-
dum; Deinde, Do-
ctrina cognoscen-
dum: Natura ex
operibus; Doctri-
na ex predicatio-
nibus.
Tertul. ad ver.
Marcion. lib. 1.
cap. 28.

less condemned upon the testimony of Texts of Scripture, which may, under their words, couch Senses seemingly contrary thereto; In regard that every Expression of Scripture is not tied to so strict conditions, as every Effect of Nature: Nor doth God less admirably discover himself unto us in Nature's Actions, than in the Scriptures Sacred Dictions. Which peradventure Tertul-
lian intended to express in those words: (c) *We conclude, God is known; first, by Nature, and then again more particularly known by Doctrine: by Nature, in his Works; by Doctrine, in his Word preached.*

But I will not hence affirm, but that we ought to have an extraordinary Esteem for the Places of Sacred Scripture, nay, being come to a certainty in any Natural Conclusions, we ought to make use of them, as most apposite helps to the true Exposition of the same Scriptures; and to the investigation of those Senses which are necessarily contained in them, as most true, and concordant with the Truths demonstrated.

This maketh me to suppose, that the Authority of the Sacred Volumes was intended principally to persuade men to the belief of those Articles and Propositions, which, by reason they surpass all humane discourse, could not by any other Science, or by any other means be made credible, than by the Mouth of the Holy Spirit it self. Besides that, even in those Propositions, which are not *de Fide*, the Authority of the same Sacred Leaves ought to be preferred to the Authority of all Humane Sciences that are not written in a Demonstrative Method, but either with bare Narrations, or else with probable Reasons; and this I hold to be so far convenient and necessary, by how far the said Divine Wisdome surpasseth all humane Judgment and Conjecture. But that that self same God who hath indued us with Senses, Discourse, and Understanding hath intended, laying aside the use of these, to give the knowledg of those things by other means, which we may attain by these, so as that even in those Natural Conclusions, which either by Sensible Experiments or Necessary Demonstrations are set before our eyes, or our Understanding, we ought to deny Sense and Reason, I do not conceive that I am bound to believe it; and especially in those Sciences, of which but a small part, and that divided into Conclusions is to be found in the Scripture: Such as, for instance, is that of *Astronomy*, of which there is so small a part in Holy Writ, that it doth not so much as name any of the Planets, except the Sun and the Moon, and once or twice onely *Venus* under the name of *Lucifer*. For if the Holy Writers had had any intention to persuade People to believe the Dispositions and Motions of the Cœlestial Bodies; and that consequently we are still to derive that know-
ledge

ledge from the Sacred Books they would not, in my opinion, have spoken so little thereof, that it is as much as nothing, in comparison of the infinite admirable Conclusions, which in that Science are comprized and demonstrated. Nay, that the Authours of the Holy Volumes did not only not pretend to teach us the Constitutions and Motions of the Heavens and Stars, their Figures, Magnitudes, and Distances, but that intentionally (albeit that all these things were very well known unto them) they forbore to speak of them, is the opinion of the Most Holy & Most Learned Fathers: and in St. Augustine we read the following words.

(c) It is likewise commonly asked, of what Form and Figure we may believe Heaven to be, according to the Scriptures: For many contend much about those matters, which the greater prudence of our Authors hath forbore to speak of, as nothing furthering their Learners in relation to a blessed life; and, (which is the chiefest thing) taking up much of that time which should be spent in holy exercises. For what is it to me whether Heaven, as a Sphere, doth on all sides environ the Earth, a Mass ballanced in the middle of the World; or whether like a Dish it doth onely cover or overcast the same? But because belief of Scripture is urged for that cause, which we have oft mentioned, that is, That none through ignorance of Divine Phrases; when they shall find any thing of this nature in, or hear any thing cited out of our Bibles which may seem to oppose manifest Conclusions, should be induced to suspect their truth, when they admonish, relate, & deliver more profitable matters Briefly be it spoken, touching the Figure of Heaven, that our Authours knew the truth: But the H. Spirit would not, that men should learn what is profitable to none for salvation.

Sed quia de Fide agitur Scripturarum, propter illam causam, quam non semel commemoravimus, Ne scilicet quisquam eloquia divina non intelligens, cum de his rebus tale aliquid vel invenerit in Libris Nostris, vel ex illis audierit, quod perceptis assertivis adversari videatur, nullo modo eis, cetera utilia momentibus, vel narrantibus, vel prænuntiatis, credat: Brevis descendendum est, de figura Cæli, hoc scisse Autores nostros, quod veritas habet: Sed Spiritum Dei, qui per istos loquebatur, noluisse ista docere homines, nulli ad salutem profutura. D. August. Lib. 2. De Gen. ad literam, Cap. 9. Idem etiam legitur apud Petrum Lombardum Magistrum Sententiarum.

And the same intentional silence of these sacred Penmen in determining what is to be believed of these accidents of the Celestial Bodies, is again hinted to us by the same Father in the ensuing 10. Chapter upon the Question, Whether we are to believe that Heaven moveth, or standeth still, in these words: (d) There are some of the Brethren that start a question concerning the motion of Heaven, Whether it be fixed, or moved: For if it be moved (say they) how is it a Firmament? If it stand still, how do these Stars which are held to be fixed go round from East to West, the more Northern performing shorter Circuits near the Pole; so that Heaven, if there be another Pole, to us unknown, may seem to revolve upon some other Axis; but if there be not another Pole, it may be thought to move as a Discus? To whom I reply, That

(c) Quæritur etiam solet, quæ forma & figura Cæli credenda sit secundum Scripturas nostras: Multi enim multam disputant de iis rebus, quas majori prudentia nostri Autores omiserunt, ad beatam vitam non profuturas discensibus, & occupantibus (quod prius est) multum proficua, & rebus salubribus impendenda temporum spatia. Quid enim ad me pertinet, utrum Cælum, sicut Sphæram, undique circumscribat Terram, in media Mundi mole librata; an eam ex una parte desuper, velut discum, operiat?

(d) De Motu etiam Cæli, nonnulli fratres quaestiones movent, utrum stet, an moveatur; quia si moveatur, inquam, quomodo Firmamentum est? Si autem stet, quomodo Sydera quæ in ipso fixa creduntur, ab Oriente in Occidentem circue-

ant, Sententio-
nalibus breviores
gyros juxta cardi-
nem peragentibus;
ut Cælum, si est a-
lius nobis occultus
cardo, ex alio ver-
tice, sicut Sphæra;
si autem nullus a-
lius cardo est, vel
ut discus rotari
videatur? Quibus
respondet, Multum
subtilibus & labo-
riosis rationibus
ista perquiri, ut ve-
re percipiatur, u-
trum ita, an non
ita sit, quibus in-
mundis atque tra-
ctandis, nec mihi
jam tempus est, nec
illis esse debet, qui
ad salutem suam,
è Sanctæ Ecclesiæ
necessaria utilitate
cupimus informa-
ri:

*Card. Baronius.

Spiritui sancto
mentem fuisse, nos
docere, quomodo ad
Cælum eatur: non
autem, quomodo
Cælum gradiatur.
Cardinal. Bar.

(e) Illud etiam
diligenter caven-
dum, & omnino
fugiendum est, ne
in tractanda Mo-
sis Doctrina, quic-
quam affirmare &
asseranter sen-
tiamus & dica-
mus, quod repug-
net manifestis ex-
perimentis & rationibus Philosophiæ, vel aliarum Disciplinarum. Namque cum Verum omne semper cum Vero
congruat, non potest Veritas Sacrarum Litterarum, Veris Rationibus & Experimentis Humanarum Doctrina-
rum esse contraria, Peier. in Gen. circa Principium.

(f) Si manife-
sta certa que Rati-
oni, velut sancta-
rum Litterarum
objicitur autors-

these points require many subtil and profound Reasons, for the making out whether they be really so, or no; the undertaking and discussing of which is neither consistent with my leasure, nor their duty, whom I desire to instruct in the necessary matters more directly conducing to their salvation, and to the benefit of The Holy Church.

From which (that we may come nearer to our particular case) it necessarily followeth, that the Holy Ghost not having intended to teach us, whether Heaven moveth or standeth still; nor whether its Figure be in Form of a Sphere, or of a Discus, or distended in Planum: Nor whether the Earth be contained in the Centre of it, or on one side; he hath much less had an intention to assure us of other Conclusions of the same kinde, and in such a manner, connected to these already named, that without the determination of them, one can neither affirm one or the other part; which are, The determining of the Motion and Rest of the said Earth, and of the Sun. And if the same Holy Spirit hath purposely pretermitted to teach us those Propositions, as nothing concerning his intention, that is, our salvation; how can it be affirmed, that the holding of one part rather than the other, should be so necessary, as that it is *de Fide*, and the other erroneous? Can an Opinion be Heretical; and yet nothing concerning the salvation of souls? Or can it be said that the Holy Ghost purposed not to teach us a thing that concerned our salvation? I might here insert the Opinion of an Ecclesiastical * Person, raised to the degree of Eminentissimo, to wit, That the intention of the Holy Ghost, is to teach us how we shall go to Heaven, and not how Hea-

ven goeth. But let us return to consider how much necessary Demonstrations, and sensible Experiments ought to be esteemed in Natural Conclusions; and of what Authority Holy and Learned Divines have accounted them, from whom amongst an hundred other attestations, we have these that follow: (e) We must also carefully heed and altogether avoid in handling the Doctrine of Moses, to avouch or speak any thing affirmatively and confidently which contradicteth the manifest Experiments and Reasons of Philosophy, or other Sciences. For since all Truth is agreeable to Truth, the Truth of Holy Writ cannot be contrary to the solid Reasons and Experiments of Humane Learning.

Namque cum Verum omne semper cum Vero congruat, non potest Veritas Sacrarum Litterarum, Veris Rationibus & Experimentis Humanarum Doctrinarum esse contraria, Peier. in Gen. circa Principium.

And in St. Augustine we read: (f) If any one shall object the Authority of Sacred Writ, against clear and manifest Reason, he that doth so, knows not what he undertakes: For he objects against

against the Truth, not the sense of the Scripture (which is beyond his comprehension) but rather his own; not what is in it, but what, finding it in himself, he fancied to be in it.

This granted, and it being true, (as hath been said) that two Truths cannot be contrary to each other, it is the office of a Judicious Expofitor to study to finde the true Senses of Sacred Texts, which undoubtedly shall accord with those Natural Conclusions, of which manifest Sense and Necessary Demonstrations had before made us sure and certain. Yea, in regard that the Scriptures (as hath been said) for the Reasons alledged; admit in many places Expofitions far from the Sense of the words; and moreover, we not being able to affirm, that all Interpreters speak by Divine Inspiration; For (if it were so) then there would be no difference between them about the Senses of the same places; I should think that it would be an act of great prudence to make it unlawful for any one to usurp Texts of Scripture, and as it were to force them to maintain this or that Natural Conclusion for truth, of which Sense, & Demonstrative, and necessary Reasons may one time or other assure us the contrary. For who will prescribe bounds to the Wits of men? Who will assert that all that is sensible and knowable in the World is already discovered and known? Will not they that in other points disagree with us, confess this (and it is a great truth) that *Ex qua scimus, sint minima pars eorum quæ ignoramus?* That those Truths which we know, are very few, in comparison of those which we know not? Nay more, if we have it from the Mouth of the Holy Ghost, that *Deus tradidit Mundum disputationi eorum, ut non inveniat homo opus, quod operatus est Deus ab initio ad finem:* One ought not, as I conceive, to stop the way to free Philosophizing, touching the things of the World, and of Nature, as if that they were already certainly found, and all manifest: nor ought it to be counted rashness, if one do not sit down satisfied with the opinions now become as it were common; nor ought any persons to be displeased, if others do not hold, in natural Disputes to that opinion which best pleaseth them; and especially touching Problems that have, for thousands of years, been controverted amongst the greatest Philosophers, as is the Stability of the Sun, and Mobility of the Earth, an opinion held by *Pythagoras*, and by his whole Sect; by *Heracledes Ponticus*, who was of the same opinion; by *Phylolaus*, the Master of *Plato*; and by *Plato* himself, as *Aristotle* relateth, and of which *Plutarch* writeth in the life of *Numa*, that the said *Plato*, when he was grown old, said, It is a most absurd thing to think otherwise: The same was believed by *Aristarchus Samius*, as we have it in *Archimedes*; and probably by *Archimedes* himself;

ritas, non intelligit, qui hoc facit; & non Scriptura sensum (ad quem penetrare non potuit) sed suum potius obicit veritatem: nec id quod in ea, sed quod in se ipso velut pro ea invenit, opponit. Epist. 7. ad Marcellinum.

Ecclesiast. cap. 3.

self; by *Nicetas* the Philosopher, upon the testimony of *Scicero*, and by many others. And this opinion hath, finally, been amplified, and with many Observations and Demonstrations confirmed by *Nicholaus Copernicus*. And *Seneca*, a most eminent Philosopher, in his Book *De Cometis*, advertizeth us that we ought, with great diligence, seek for an assured knowledge, whether it be Heaven, or the Earth, in which the Diurnal Conversion resides.

And for this cause, it would probably be prudent and profitable counsel, if besides the Articles which concern our Salvation, and the establishment of our Faith (against the stability of which there is no fear that any valid and solid Doctrine can ever rise up) men would not aggregate and heap up more, without necessity: And if it be so, it would certainly be a preposterous thing to introduce such Articles at the request of persons who, besides that we know not that they speak by inspiration of Divine Grace, we plainly see that there might be wished in them the understanding which would be necessary first to enable them to comprehend, and then to discuss the Demonstrations wherewith the subtiler Sciences proceed in confirming such like Conclusions. Nay, more I should say, (were it lawful to speak my judgment freely on this Argument) that it would haply more suit with the *Decorum* and Majesty of those Sacred Volumes, if care were taken that every shallow and vulgar Writer might not authorize his Books (which are not seldome grounded upon foolish fancies) by inserting into them Places of Holy Scripture, interpreted, or rather distorted to Senses as remote from the right meaning of the said Scripture, as they are near to derision, who not without ostentation flourish out their Writings therewith. Examples of such like abuses there might many be produced, but for this time I will confine my self to two, not much besides these matters of *Astronomy*: One of which, is that of those Pamphlets which were published against the *Medicean* Planets, of which I had the fortune to make the discovery; against the existence of which there were brought many places of Sacred Scripture: Now, that all the World seeth them to be Planets, I would gladly hear with what new interpretations those very Antagonists do expound the Scripture, and excuse their own simplicity. The other example is of him who but very lately hath Printed against *Astronomers* and *Philosophers*, that the Moon doth not receive its light from the Sun, but is of its own nature resplendent: which imagination he in the close confirmeth, or, to say better, perswadeth himself that he confirmeth by sundry Texts of Scripture, which he thinks cannot be reconciled unlesse his opinion should be true and necessary. Nevertheless,
the

the Moon of it self is Tenebrose, and yet it is no lesse lucid than the Splendor of the Sun.

Hence it is manifest, that these kinde of Authors, in regard they did not dive into the true Sence of the Scriptures, would (in case their authority were of any great moment) have imposed a necessity upon others to believe such Conclusions for true as were repugnant to manifest Reason, and to Sense. Which abuse *Deus avertat*, that it do not gain Countenance and Authority; for if it should, it would in a short time be necessary to proscribe and inhibit all the Contemplative Sciences. For being that by nature the number of such as are very unapt to understand perfectly both the Sacred Scriptures, and the other Sciences is much greater than that of the skilfull and intelligent; those of the first sort superficially running over the Scriptures, would arrogate to themselves an Authority of decreeing upon all the Questions in Nature, by vertue of some Word by them misunderstood, and produced by the Sacred Pen-men to another purpose: Nor would the small number of the Intelligent be able to repress the furious Torrent of those men, who would finde so many the more followers, in that the gaining the reputation of Wise men without pains or Study, is far more grateful to humane Nature, than the consuming our selves with restless contemplations about the most painfull Arts. Therefore we ought to return infinite thanks to Almighty God, who of his Goodness freeth us from this fear, in that he depriveth such kinde of persons of all Authority and, repositeth the Consulting, Resolving, and Decreeing upon so important Determinations in the extraordinary Wisdom and Candor of most Sacred Fathers; and in the Supream Authority of those, who being guided by his Holy Spirit, cannot but determine Holily: So ordering things, that of the levity of those other men, there is no account made. This kinde of men are those, as I believe, against whom, not without Reason, Grave, and Holy Writers do so much inveigh; and of whom in particular S. Hierom writeth:

(g) This (Scilicet the Sacred Scripture) the talking old woman, the doting old man, the talkative Sophister, all venture upon, lacerate, teach, and that before they have learnt it. Others induced by Pride, diving into hard words, Philosophate amongst Women, touching the Holy Scriptures. Others (Oh shameful!) Learn of Women what they teach to Men; and, as if this were nothing, in a certain facility of words, I may say of confidence, expound to others what they understand not themselves. I forbear to speak of those of my own Profession, who, if after humane Learning they chance to attain to the Holy Scriptures, and tickle the ears of the people with affected and Studied expressions, they affirm that all they say, is to be entertained as the Law of God; and

(g) Hanc (Scilicet Sacram Scripturam) garrula anus, hanc delirans senex, hanc Sophista verbosus, hanc universi presumunt, lacerant, docent, antequam discant: Alij, adducto supercilio, grandia verba trutinantes, inter mulierculas, de Sacris Litteris Philosophantur. Alij discunt, pro pudor! à feminis, quod viros docent,

Et ne parum hoc
sit, quodam faci-
litate verborum,
immo audacia, edis-
serunt aliis, quod
ipsi non intelli-
gunt. Taceo de
mei similibus, qui
si forte ad Scriptu-
ras Sanctas, post
seculares litteras
venerint, & ser-
mone composito,
aurum populi mul-
serint; quicquid
dixerint, hoc legem
Dei putant:
nec scire dignan-
tur, quid Prophe-
ta, quid Apostoli
fenserint, sed ad
sensum suum, in-
congrue aptant re-
sponsiones: Quasi
grande sit, & non
vitiocissimum do-
cendi genus, de-
pravare sententi-
as, & ad volun-
tatem suam Scri-
pturas trahere re-
pugnantem. Je-
ron. Epist. ad
Paul. 103.

and not stooping to learn what the Prophets and Apostles held, they force incongruous testimonies to their own Sense: As if it were the genuine, and not corrupt way of teaching to deprave Sentences, and Wrest the Scripture according to their own singular and contradictory humour.

I will not rank among these same secular Writers any Theologists, whom I repute to be men of profound Learning, and sober Manners, and therefore hold them in great esteem and veneration: Yet I cannot deny but that I have a certain scruple in my mind, and consequently am desirous to have it removed, whilst I hear that they pretend to a power of constraining others by Authority of the Scriptures to follow that opinion in Natural Disputations, which they think most agreeth with the Texts of that: Holding withall, that they are not bound to answer the Reasons and Experiments on the contrary: In Explication and Confirmation of which their judgement they say, That Theologie being the Queen of all the Sciences, she ought not upon any account to stoop to accomodate herself to the Positions of the rest, less worthy and inferior to her: But that they ought to refer themselves to her (as to their Supreme Emperess) and change and alter their Conclusions, according to Theological Statutes and Decrees. And they further add, That if in the inferior Science there should be any Conclusion certain by virtue of Demonstrations or experiments, to which there is found in Scripture another Conclusion repugnant; the very Professors of that Science ought of themselves to resolve their Demonstrations, and discover the falacies of their own Experiments, without repairing to Theologers and Textuaries, it not suiting (as hath been said) with the dignity of Theologie to stoop to the investigation of the falacies of the inferior Sciences: But it sufficeth her, to determine the truth of the Conclusion with her absolute Authority, and by her infallibility. And then the Natural Conclusions in which they say that we ought to abide by the meer Authority of the Scripture, without glossing, or expounding it to Senses different from the Words, they affirm to be Those of which the Scripture speaketh alwaies in the same manner; and the Holy Fathers all receive, and expound to the same Sense.

Now as to these Determinations, I have had occasion to consider some particulars (which I will purpose) for that I was made cautious thereof, by those who understand more than I in these businesses, and to whose judgements I alwaies submit my self. And first I could say, that there might possibly a certain kinde of equivocation interpose, in that they do not distinguish the preeminences whereby Sacred Theologie meriteth the Title of Queen. For

For it might be called so, either because that that which is taught by all the other Sciences, is found to be comprized and demonstrated in it, but with more excellent means, and with more sublime Learning; in like manner, as for example; The Rules of measuring of Land, & of Accountantship are much more excellently contained in the Arithmetick and Geometry of *Euclid*, than in the Practises of Surveyours and Accomptants: Or because the Subject about which *Theologie* is conversant, excelleth in Dignity all the other Subjects, that are the Matters of other Sciences: As also because its Documents are divulged by nobler waies. That the Title and Authority of Queen belongeth to *Theologie* in the first Sense, I think that no Theologers will affirm, that have but any insight into the other Sciences; of which there are none (as I believe) that will say that Geometry, Astronomy Musick, and Medicine are much more excellently and exactly contained in the Sacred Volumes, than in the Books of *Archimedes*, in *Ptolomy*, in *Boetius*, and in *Galen*. Therefore it is probable that the Regal Preheminence is given her upon the second account, namely, By reason of the Subject, and the admirable communicating of the Divine Revelations in those Conclusions which by other means could not be conceived by men, and which chiefly concern the acquit of eternal Beatitude. Now if *Theologie* being conversant about the loftiest Divine Contemplation, and residing for Dignity in the Regal Throne of the Sciences, (whereby she becometh of highest Authority) descendeth not to the more mean and humble Speculations of the inferior Sciences: Nay; (as hath been declared above) hath no regard to them, as not concerning Beatitude; the Professors thereof ought not to arrogate to themselves the Authority to determine of Controversies in those Professions which have been neither practised nor studied by them. For this would be as if an Absolute Prince, knowing that he might freely command, and cause himself to be obeyed, should (being neither Physician nor Architect) undertake to administer Medicines, and erect Buildings after his own fashion, to the great endangering of the lives of the poor Patients, and to the manifest destruction of the Edifices.

Again, to command the very Professors of *Astronomy*, that they of themselves see to the confuting of their own Observations and Demonstrations, as those that can be no other but Falacies and Sophismes, is to enjoin a thing beyond all possibility of doing: For it is not onely to command them that they do not see that which they see, and that they do not understand that which they understand; but that in seeking, they finde the contrary of that which they happen to meet with. Therefore before that this is to be done, it would be necessary that they were

K k k

shewed

shewed the way how to make the Powers of the Soul to command one another, and the inferior the Superior; so that the imagination and will might, and should believe contrary to what the Intellect understands: I still mean in Propositions purely Natural, and which are not *de Fide*, and not in the Supernatural, which are *de Fide*.

I would entreat these Wise and Prudent Fathers, that they would withal diligence consider the difference that is between Opinable and Demonstrative Doctrines: To the end, that well weighing in their minds with what force Necessary Illations oblige, they might the better ascertain themselves, that it is not in the Power of the Professors of Demonstrative Sciences to change their Opinions at pleasure, and apply themselves one while to one side, and another while to another; and that there is a great difference between commanding a Methametician or a Philosopher, and the disposing of a Lawyer or a Merchant; and that the demonstrated Conclusions touching the things of Nature and of the Heavens cannot be changed with the same facility, as the Opinions are touching what is lawful or not in a Contract, Bargain, or Bill of Exchange. This difference was well understood by the Learned and Holy Fathers, as their having been at great pains to confute many Arguments, or to say better, many Philosophical Fallacies, doth prove unto us; and as may expressly be read in some of them, and particularly we have in *S. Augustine* the following words: (g) *This is to be held for an undoubted Truth, That we may be confident, that whatever the Sages of this World have demonstrated touching Natural Points, is no waies contrary to our Bibles: And in case they teach any thing in their Books that is contrary to the Holy Scriptures, we may without any scruple conclude it to be most false; And according to our ability let us make the same appear: And let us so keep the Faith of our Lord, in whom are hidden all the Treasures of Wisdom; that we be neither seduced with the Loquacity of false Philosophy, nor scared by the superstition of a counterfeit Religion.*

From which words, I conceive that I may collect this Doctrine, namely, That in the Books of the Wise of this World, there are contained some Natural truths that are solidly demonstrated, and others again that are barely taught; and that as to the first sort, it is the Office of wise Divines to shew that they are not contrary to the Sacred Scriptures; As to the rest, taught, but not necessarily demonstrated, if they shall contain any thing contrary to the Sacred Leaves, it ought to be held undoubtedly false, and such it ought by all possible waies to be demonstrated.

If therefore Natural Conclusions veritably demonstrated, are not

(g) *Hoc indubitanter tenendum est, ut quicquid Sapientes huius Mundi, de Natura rerum veraciter demonstrare potuerint, ostendamus, nostris libris non esse contrarium: quicquid autem illi in suis voluminibus, contrarium Sacris Litteris docent, sine ulla dubitatione credamus, id falsissimum esse, & quoquo modo possimus, etiam ostendamus; atque ita teneamus Fidem Domini nostri, in qua sunt absconditi omnes thesauri Sapientiae, ut neque falsa Philosophiae loquacitate seducamur, neque simulata Religione superstitione terreamur.*
Gen. ad Litteram. lib. 1. Cap. 25.

not to be postponed to the Places of Scripture, but that it ought to be shewn how those Places do not interfere with the said Conclusions; then its necessary before a Physical Proposition be condemned; to shew that it is not necessarily demonstrated; and this is to be done not by them who hold it to be true, but by those who judge it to be false. And this seemeth very reasonable, and agreeable to Nature; that is to say, that they may much more easily find the fallacies in a Discourse, who believe it to be false, than those who account it true and concludent. Nay, in this particular it will come to passe, that the followers of this opinion, the more that they shall turn over Books, examine the Arguments, repeat the Observations, and compare the Experiments, the more shall they be confirmed in this belief. And your Highness knoweth what happened to the late Mathematick Professor in the University of *Pisa*, Who betook himself in his old age to look into the Doctrine of *Copernicus*, with hope that he might be able solidly to confute it (for that he held it so far to be false, as that he had never studied it) but it was his fortune, that as soon as he had understood the grounds, proceedings, and demonstrations of *Copernicus*, he found himself to be perswaded, and of an opposer became his most confident Defender. I might also nominate other Mathematicians, who being moved by my last Discoveries, have confessed it necessary to change the formerly received Constitution of the World, it not being able by any means to subsist any longer.

* P. Clavius the Jesuite.

If for the banishing this Opinion and Hypothesis out of the World, it were enough to stop the mouth of one alone, as it may be they perswade themselves who measuring others judgements by their own, think it impossible that this Doctrine should be able to subsist and finde any followers, this would be very easie to be done, but the business standerh otherwise: For to execute such a determination, it would be necessary to prohibite not onely the Book of *Copernicus*, and the Writings of the other Authors that follow the same opinion, but to interdict the whole Science of *Astronomy*; and which is more, to forbid men looking towards Heaven, that so they might not see *Mars* and *Venus* at one time neer to the Earth, and at another farther off, with such a difference that the latter is found to be forty times, and the former sixty times bigger in surface at one time than at another; and to the end, that the same *Venus* might not be discovered to be one while round, and another while forked, with most subtil hornes: and many other sensible Observations which can never by any means be reconciled to the *Ptolomaick* Systeme, but are unanswerable Arguments for the *Copernican*.

But the prohibiting of *Copernicus* his Book, now that by many

K k k 2

new

new Observations, and by the application of many of the Learned to the reading of him, his Hypothesis and Doctrine doth every day appear to be more true, having admitted and tolerated it for so many years, whilst he was lesse followed, studied, and confirmed, would seem, in my judgment, an affront to Truth, and a seeking the more to obscure and suppress her, the more she sheweth her self clear and perspicuous.

The abolishing and censuring, not of the whole Book, but onely so much of it as concerns this particular opinion of the *Earths Mobility*, would, if I mistake not, be a greater detriment to souls, it being an occasion of great scandal, to see a Position proved, and to see it afterwards made an Heresie to believe it.

The prohibiting of the whole Science, what other would it be but an open contempt of an hundred Texts of the Holy Scriptures, which teach us, That the Glory, and the Greatnesse of Almighty God is admirably discerned in all his Works, and divinely read in the Open Book of Heaven? Nor let any one think that the Lecture of the lofty conceits that are written in those Leaves finish in only beholding the Splendour of the Sun, and of the Stars, and their rising and setting, (which is the term to which the eyes of bruits and of the vulgar reach) but there are couched in them mysteries so profound, and concepts so sublime, that the vigils, labours, and studies of an hundred and an hundred acute Wits, have not yet been able thorowly to dive into them after the continual disquisition of some thousands of years. But let the Unlearned believe, that like as that which their eyes discern in beholding the aspect of a humane body, is very little in comparison of the stupendious Artifices, which an exquisite and curious Anatomist or Philosopher finds in the same when he is searching for the use of so many Muscles, Tendons, Nerves, and Bones; and examining the Offices of the Heart, and of the other principal Members, seeking the seat of the vital Faculties, noting and observing the admirable structures of the Instruments of the Senses, and, without ever making an end of satisfying his curiosity and wonder, contemplating the Receptracles of the Imagination, of the Memory, and of the Understanding; So that which represents it self to the meer sight, is as nothing in comparison and proportion to the strange Wonders, that by help of long and accurate Observations the Wit of Learned Men discovereth in Heaven. And this is the substance of what I had to consider touching this particular.

In the next place, as to those that adde, That those Natural Propositions of which the Scripture still speaks in one constant tenour, and which the Fathers all unanimously receive in the same sense, ought to be accepted according to the naked and
literal

literal sense of the Words, without glosses and interpretations; and received and held for most certain and true; and that consequently the Mobility of the Sun, and Stability of the Earth, as being such, are *de Fide* to be held for true, and the contrary opinion to be deemed Heretical: I shall propose to consideration, in the first place, That of Natural Propositions, some there are, of which all humane Science and Discourse can furnish us only with some plausible opinion, and probable conjecture rather than with any certain and demonstrative knowledge; as for example, whether the Stars be animated: Others there are, of which we have, or may confidently believe that we may have, by Experiments, long Observations, and Necessary Demonstrations an undubitable assurance; as for instance, whether the Earth and Heavens move, or not; whether the Heavens are Spherical, or otherwise. As to the first sort, I doubt not in the least, that if humane Ratiocinations cannot reach them, and that consequently there is no Science to be had of them, but only an Opinion or Belief, we ought fully and absolutely to comply with the meer Verbal Sense of the Scripture: But as to the other Positions, I should think (as hath been said above) That we are first to ascertain our selves of the fact it self, which will assist us in finding out the true senses of the Scriptures; which shall most certainly be found to accord with the fact demonstrated, for two truths can never contradict each other. And this I take to be a Doctrine orthodox and undoubted, for that I finde it written in Saint *Augustine*, who speaking to our point of the Figure of Heaven, and what it is to be believed to be, in regard that which Astronomers affirm concerning it seemeth to be, contrary to the Scripture, (they holding it to be rotund, and the Scripture calling it as it were a * Curtain, determineth that we are not at all to regard that the Scripture contradicts Astronomers; but to believe its Authority, if that which they say shall be false, and founded only on the conjectures of humane infirmity: but if that which they affirm be proved by indubitable Reasons, this Holy Father doth not say, that the Astronomers are to be enjoined, that they themselves resolving and renouncing their Demonstrations do declare their Conclusion to be false, but saith, that it ought to be demonstrated, That what is said in Scripture of a Curtain is not contrary to their true Demonstrations. These are his words: (b) But some object; How doth it appear, that the saying in our Bibles, Who stretcheth out the Heaven as a Curtain, maketh not against those who maintain the Heavens to be in figure of a Sphere? Let it be so, if that be false which they affirme: For that is truth which is spoke by Divine Authority, rather than

* Pelle, a Skin in the Original, but in our Bibles a Curtain.

(b) Sed ais aliquis, quomodo non est contrarium illi, qui figuram Sphærae Cælo tribuit, quod scriptum est in Libris Nostriis, Qui extendit Cælum, sicut pellem?

Sit sane contrarium, si falsum est, quod illi dicunt: hoc enim verum est, quod Divina dicitur auctoritas, potius quam illud, quod humana infirmitas conjicit. Sed si forte illud talibus illis documentis probare poterint, ut dubitari inde non debeat: demonstrandum est, hoc quod a quod nos est de Pelle dictum, veris illis rationibus non esse contrarium.

(1) Quod licet in presenti facile non possit comprehendi; arbitror tamen, in processu tractandarum Scripturarum, opportuniore loca posse occurrere, ubi nobis de hac re, secundum Sancta auctoritatis Litteras, esse non ostendere certum aliquid, tamen credere licebit. Nunc autem, servata semper moderata ratione pia gravitate, nihil credere de re obscura temere debemus; ne forte, quod postea veritas patefecerit, quamvis Libris Sanctis, sive Testamenti veteris, sive, novi nullo modo esse possit aversum, tamen propter amorem nostris erroris oderimus.

Id. D. Aug. in Gen. ad Litteram, lib. 1. in fine.

that which proceeds from Humane Infirmitie. But if peradventure they should be able to prove their Position by such Experiments as puts it out of question, it is to be proved, that what is said in Scripture concerning a Curtain, doth in no wise contradict their manifest Reasons.

He proceedeth afterwards to admonish us that we ought to be no less careful and observant in reconciling a Text of Scripture with a demonstrated Natural Proposition, than with another Text of Scripture which should sound to a contrary Sense. Nay methinks that the circumspection of this Saint is worthy to be admired and imitated, who even in obscure Conclusions, and of which we may assure our selves that we can have no knowledge or Science by humane demonstration, is very reserved in determining what is to be believed, as we see by that which he writeth in the end of his second Book, *de Genesi ad Litteram*, speaking, whether the Stars are to be believed animate: (2) Which particular, although (at present) it cannot easily be comprehended, yet I suppose in our farther Progress of handling the Scriptures, we may meet with some more pertinent places, upon which it will be permitted us (if not to determine any thing for certain, yet) to suggest somewhat concerning this matter, according to the dictates of Sacred Authority. But now, the moderation of pious gravity being alwaies observed, we ought to receive nothing rashly in a doubtful point, least perhaps we reject that out of respect to our Error, which hereafter Truth may discover, to be in no wise repugnant to the Sacred Volumes of the Old and New Testament.

By this and other places (if I deceive not my self) the intent of the Holy Fathers appeareth to be, That in Natural questions, and which are not *de Fide*, it is first to be considered, whether they be indubitably demonstrated, or by sensible Experiments known; or whether such a knowledge and demonstration is to be had; which having obtained, and it being the gift of God, it ought to be applied to find out the true Sences of the Sacred Pages in those places, which in appearance might seem to speak to a contrary meaning: Which will unquestionably be pierced into by Prudent Divines, together with the occasions that moved the Holy Ghost, (for our exercise, or for some other reason to me unknown) to veil it self sometimes under words of different significations.

As to the other point, Of our regarding the Primary Scope of those Sacred Volumes, I cannot think that their having spoken alwaies in the same tenour, doth any thing at all disturb this Rule. For if it hath been the Scope of the Scripture by way of condescension to the capacity of the Vulgar at any time, to express

press a Proposition in words, that bear a sense different from the Essence of the said Proposition; why might it not have observed the same, and for the same respect, as often as it had occasion to speak of the same thing? Nay I conceive, that to have done otherwise, would but have encreased the confusion, and diminished the credit that these Sacred Records ought to have amongst the Common People.

Again, that touching the Rest and Motion of the Sun and Earth, it was necessary, for accommodation to Popular Capacity, to assert that which the Litteral sense of the Scripture importeth, experience plainly proveth: For that even to our dayes people far less rude, do continue in the same Opinion upon Reasons, that if they were well weighed and examined, would be found to be extream trivial, and upon Experiments, either wholly false, or altogether besides the purpose. Nor is it worth while to go about to remove them from it, they being incapable of the contrary Reasons that depend upon too exquisite Observations, and too subtil Demonstrations, grounded upon Abstractions, which, for the comprehending of them, require too strong an Imagination. Whereupon, although that the Stability of Heaven, and Motion of the Earth should be more than certain and demonstrated to the Wise; yet nevertheless it would be necessary, for the conservation of credit amongst the Vulgar, to affirm the contrary: For that of a thousand ordinary men, that come to be questioned concerning these particulars, its probable that there will not be found so much as one that will not answer that he thinketh, and so certainly he doth, that the Sun moveth, and the Earth standeth still. But yet none ought to take this common Popular Assent to be any Argument of the truth of that which is affirmed: For if we should examine these very men touching the grounds and motives by which they are induced to believe in that manner; and on the other side should hear what Experiments and Demonstrations persuade those few others to believe the contrary, we should finde these latter to be moved by most solid Reasons, and the former by simple appearances, and vain and ridiculous occurrences. That therefore it was necessary to assign Motion to the Sun, and Rest to the earth, lest the shallow capacity of the Vulgar should be confounded, amused, and rendred obstinate and contumacious, in giving credit to the principal Articles, and which are absolutely *de fide*, it is sufficiently obvious. And if it was necessary so to do, it is not at all to be wondred at, that it was with extraordinary Wildom so done, in the Divine Scriptures.

But I will alledge further, That not onely a respect to the Incapacity of the Vulgar, but the current Opinion of those times made

(k) *Quasi non multa in Scripturis Sanctis dicantur juxta opinionem illius temporis quo gesta referunt, & non juxta quod rei veritas continetur.* D. Hieron. in c. 28. Jerem.

(l) *Consuetudinis Scripturarum est, ut opinio multarum rerum significet Historicis, quomodo eo tempore ab omnibus credebatur.* In cap. 13. Matth.
D. Thomas, in cap. 26. Job. v. 7.

made the Sacred Writers, in the points that were not necessary to salvation, to accommodate themselves more to the received use, than to the true Essence of things: Of which S. Hierom treating, writeth: (k) *As if many things were not spoken in the Holy Scriptures according to the judgement of those times in which they were acted, and not according to that which truth contained.* And elsewhere, the same Saint: (l) *It is the custome for the Pen-men of Scripture, to deliver their Judgments in many things, according to the common received opinion that their times had of them.* And S. Thomas Aquinas in Job upon those words, *Qui extendit Aquilonem super vacuum, & appendit Terram super nihilum*: Noteth that the Scripture calleth that space *Vacuum* and *Nihilum*, which imbraceth and environeth the Earth, and which we know, not to be empty, but filled with Air. Neverthelesse, saith he, The Scripture to comply with the apprehension of the Vulgar, who think that in that same space there is nothing, calleth it *Vacuum* and *Nihilum*. Here the words of S. Thomas, *Quod de superiori Hemisphaerio Caeli nihil nobis apparet, nisi spatium aëre plenum, quod vulgares homines reputant Vacuum; loquitur enim secundum existimationem vulgarium hominum, prout est mos in Sacra Scriptura.* Now from this Place I think one may very Logically argue, That the Sacred Scripture for the same respect had much more reason to phrase the Sun moveable, and the Earth immoveable. For if we should try the capacity of the Common People, we should find them much more unapt to be perswaded of the stability of the Sun, and Motion of the Earth, than that the space that environeth it is full of Air. Therefore if the sacred Authors, in this point, which had not so much difficulty to be beat into the capacity of the Vulgar, have notwithstanding forbore to attempt perswading them unto it, it must needs seem very reasonable that in other Propositions much more abstruse they have observed the same stile. Nay Copernicus himself, knowing what power an antiquated custome and way of conceiving things become familiar to us from our infancy hath in our Fancy, that he might not increase confusion and difficulty in our apprehensions, after he had first demonstrated, That the Motions which appear to us to belong to the Sun, or to the Firmament, are really in the Earth; in proceeding afterwards to reduce them into Tables, and to apply them to use, he calleth them the Motions of the Sun, and of the Heaven that is above the Planets; expressly terming them the Rising and Setting of the Sun and Stars; and mutations in the obliquity of the Zodiack, and variations in the points of the Equinoxes, the Middle Motion, *Anomalia*, *Prosthaphæresis* of the Sun; and such other things; which do in reality belong to the Earth: But because

cause being joyned to it, and consequently having a share in every of its motions, we cannot immediately discern them in her, but are forced to refer them to the Celestial Bodies in which they appear; therefore we call them as if they were made there, where they seem to us to be made. Whence it is to be noted how necessary it is to accommodate our discourse to our old and accustomed manner of understanding.

That, in the next place, the common consent of Fathers, in receiving a Natural Proposition of Scripture, all in the same sense ought to Authorize it so far, as to make it become a matter of Faith to believe it to be * so, I should think that it ought at most to be understood of those Conclusions onely, which have been by the said Fathers discussed, and sifted with all possible diligence, and debated on the one side, and on the other, and all things in the end concurring to disprove the one, and prove the other. But the Mobility of the Earth, and Stability of the Sun, are not of this kinde; For, that the said Opinion was in those times totally buried, and never brought amongst the Questions of the Schools, and not considered, much less followed by any one: So that it is to be believed that it never so much as entered into the thought of the Fathers to dispute it, the Places of Scripture, their own Opinion, and the assent of men having all concurred in the same judgement, without the contradiction of any one, so far as we can finde.

* Namely, according to the Literal Sense.

Besides, it is not enough to say that the Fathers all admit the stability of the Earth, &c. Therefore to believe it is a matter of Faith: But its necessary to prove that they have condemned the contrary Opinion: For I may affirm and bide by this, That their not having occasion to make satisfaction upon the same, and to discuss it, hath made them to omit and admit it, onely as current, but not as resolved and proved. And I think I have very good Reason for what I say; For either the Fathers did make reflection upon this Conclusion as controverted, or not: If not, then they could determin nothing concerning it, no not in their private thoughts; and their incogitance doth not oblige us to receive those Precepts which they have not, so much as in their intentions enjoyned. But if they did reflect and consider thereon, they would long since have condemned it, if they had judged it erroneous, which we do not find that they have done. Nay, after that some Divines have began to consider it, we find that they have not deem'd it erroneous; as we read in the Commentaries of Didacus a Sennica upon Job, in Cap. 9, v. 6. on the words, *Qui commovet Terram de loco suo*, &c. Where he at large discourseth upon the Copernican Hypothesis, and concludeth, *That the Mobility of the Earth, is not contrary to Scripture.*

Withal, I may justly question the truth of that determination, namely, That the Church enjoyneth us to hold such like Natural Con-

Conclusions as matters of Faith, onely because they bear the stamp of an unanimous Interpretation of all the Fathers: And I do suppose that it may possibly be, that those who hold in this manner, might possibly have gone about in favour of their own Opinion, to have amplified the Decretal of the Councils; which I cannot finde in this case to prohibit any other, save onely, *Perverting to Senses contrary to that of Holy Church, or of the concurrent consent of Fathers, those places; and those onely that do pertain either to Faith or Manners, or concern our edification in the Doctrine of Christianity.* And thus speaks the Council of Trent. Sess. 4. But the Mobility or Stability of the Earth, or of the Sun, are not matters of Faith, nor contrary to Manners, nor is there any one, that for the stablishing of this Opinion, will pervert places of Scripture in opposition to the Holy Church, or to the Fathers: Nay, Those who have writ of this Doctrine, did never make use of Texts of Scripture; that they might leave it still in the breasts of Grave and Prudent Divines to interpret the said Places, according to their true meaning.

And how far the Decrees of Councils do comply with the Holy Fathers in these particulars; may be sufficiently manifest, in that they are so far from enjoyning to receive such like Natural Conclusions for matters of Faith, or from censuring the contrary Opinions as erroneous; that rather respecting the Primitive and primary intention of the Holy Church, they do adjudge it unprofitable to be busied in examining the truth thereof. Let your Highness be pleased to hear once again what S. Augustine answers to those Brethren who put the Question, Whether it be true that Heaven moveth, or standeth still? (*) To these I answer, That Points of this nature require a curious and profound examination, that it may truly appear whether they be true or false; a work inconsistent with my leasure to undertake on go thorow with, nor is it any way necessary for those, whom we desire to inform of the things that more nearly concern their own salvation and The Churches Benefit.

But yet although in Natural Propositions we were to take the resolution of condemning or admitting them from Texts of Scripture unanimously expounded in the same Sense by all the Fathers, yet do I not see how this Rule can hold in our Case; for that upon the same Places we read several Expositions in the Fathers; (m) Dionysius Areopagita saying, That the *Primum Mobile*, and not the Sun stand still. Saint Augustine is of the same Opinion; (n) All the Celestial Bodies were *immoveable*. And with them concurreth *Abulensis*. But which is more, amongst the Jewish Authors (whom *Josephus* applauds) some have held, (o) That

Council. Trid. Sess.
4.

(*) His respondere, multum subtiliter, & laboriosis rationibus, ista perquiri, ut vere percipiantur, utrum ita, an non ita sit: quibus in eundis acque tractandis, nec mihi jam tempus est, nec illis esse debet, quos ad salutem suam, Sancta Ecclesia necessariam utilitatem cupimus informari.

(m) Non Solem, sed Primum Mobile immotum constituit: Dionys. Areop.

(n) Omnia corpora Celestia, immota subsistisse:

The Sun did not really stand still, but seemed so to do, during the short time in which Israel gave the overthrow to their Enemies. So for the Miracle in the time of Hezekiah, *Paulus Burgensis* is of opinion that it was not wrought on the Sun, but on the Diall. But that, in short, it is necessary to Glosse and Interpret the words of the Text in *Joshua*; when ever the Worlds Systeme is in dispute, I shall shew anon. Now finally, granting to these Gentlemen more than they demand, to wit, That we are wholly to acquiesce in the judgment of Judicious Divines, and that in regard that such a particular Disquisition is not found to have been made by the Ancient Fathers, it may be undertaken by the Sages of our Age, who having first heard the Experiments, Observations, Reasons, and Demonstrations of Philolophers and Astronomers, on the one side, and on the other (seeing that the Controversie is about Natural Problems, and Necessary Dilemma's, and which cannot possibly be otherwise than in one of the two manners in controversie) they may with competent certainty determine what Divine Inspirations shall dictate to them. But that without minutely examining and discussing all the Reasons on both sides; and without ever coming to any certainty of the truth of the Case, such a Resolution should be taken, Is not to be hoped from those who do not stick to hazard the Majesty and Dignity of the Sacred Scripture, in defending the reputation of their vain Fancies; Nor to be feared from those who make it their whole businesse, to examine with all intenseness, what the Grounds of this Doctrine are; and that only in an Holy Zeal for Truth, the Sacred Scriptures, and for the Majesty, Dignity, and Authority, in which every Christian should indeavour to have them maintained. Which Dignity, who seeth not that it is with greater Zeal desired and procured by those who, absolutely submitting themselves to the Holy Church, desire, not that this, or that opinion may be prohibited, but onely that such things may be proposed to consideration, as may the more ascertain her in the safest choice, than by those who being blinded by their particular Interest, or stimulated by malicious suggestions, preach that she should, without more ado, thunder out Curses, for that she had power so to do: Not considering that all that may be done is not alwayes convenient to be done. The Holy Fathers of old were not of this opinion, but rather knowing of how great prejudice, and how much against the primary intent of the Catholick Church, it would be to go about from Texts of Scripture to decide Natural Conclusions, touching which, either Experiments or necessary Demonstrations, might in time to come evince the contrary, of that which the naked sense of the Words foundeth, they have

(o) Solem revera non subsistisse immotum, sed pro brevi tempore, intra quod Israelitae, hostes suos fuerunt, id ira visum esse.
Ila. Cap. 2.

Lll 2

not

(p) In rebus ob-
scuris, atque à non-
fatis oculis remo-
tissimis, signa inde
scripta etiam divi-
na legerimus, que
possint salva fide,
qua imbuimur, a-
liis atque aliis pa-
rere sententiis, in
nullam earum nos
precipiti affirma-
tione ita projici-
amus, ut si forte
diligentius discus-
sa veritas ea recte
labefacta fuerit, corruiamus: non pro sententia Divinarum Scripturarum, sed pro nostra ita dimicantes, ut eam
velimus Scripturam esse, quæ nostra est, cum potius eam quæ Scripturæ est, nostram esse velle debeamus.
Divus Augustinus, in Gen. ad Litteram, lib. 2. c. 18. & seq.

He goeth on, and a little after teacheth us, that no Proposi-
tion can be against the Faith, unlesse first it be demonstrated
false; saying, (q) *Tis not all the while contrary to Faith, until it
be disproved by most certain Truth, which if it should so be, the Holy
Scripture affirm'd it not, but Humane Ignorance supposed it.*
Whereby we see that the senses which we impose on Texts of
Scripture, would be false, when ever they should disagree with
Truths demonstrated. And therefore we ought, by help of de-
monstrated Truth, to seek the undoubted sense of Scripture:
and not according to the sound of the words, that may seem
true to our weaknesse, to go about, as it were, to force Na-
ture, and to deny Experiments and Necessary Demonstra-
tions.

Let Your Highnesse be pleased to observe farther, with how
great circumspection this Holy Man proceedeth, before he af-
firmeth any Interpretation of Scripture to be sure, and in such
wise certain, as that it need not fear the encounter of any diffi-
culty that may procure it disturbance; for not contenting
himself that some sense of Scripture agreeth with some Demon-
stration, he subjoynes. (r) *But if right Reason shall demon-
strate this to be true, yet is it questionable whether in these words
of Sacred Scripture the Pen-man would have this to be under-
stood, or somewhat else, no lesse true. And in case the Context
of his Words shall prove that he intended not this, yet will not
that which he would have to be understood be therefore false, but
most true, and that which is more profitable to be known.*
hoc verum esse ve-
ra ratio demon-
straverit, adhuc
incertum erit, ut-
rum hoc in illis
verbis Sanctorum
Librorum, Scrip-
tor sentiri volue-
rit, an aliquid ali-
ud non minus ve-
rum. Quod si cetera contextio sermonis non hoc eum voluisse probaverit, non ideo falsum erit aliud, quod ipse
intelligi voluit, sed & verum, & quod nihil cognoscatur.

But that which increaseth our wonder concerning the cir-
cumspection,

(N) Si autem con-
textio Scriptura,
hoc voluisse intel-
ligi Scriptorem,
non repugnauerit,
adhuc restabit
quarere, utrum &
aliud non posuerit.

(ε) Quod si &
aliud potuisset inve-
nerimus, incertum
erit; quidnam co-
rum ille voluerit;
aut utrumque vo-
luisse non inconve-
nienter creditur, si
utriusque sententia
certa circumstan-
tia suffragatur.

And

And how much the truly Wise and Prudent Fathers are displeased with these men, who in defence of Propositions which they do not understand, do apply, and in a certain sense pawn Texts of Scripture; and afterwards go on to encrease their first Error, by producing other places less understood than the former. The same Saint declareth in the expressions following :

(y) Quid enim molestia, tristitiaque ingerant prudentibus fratribus, tenerarij; p. assumptores, satis dici non potest, cum, si quando de falsa & prava opinione sua reprehendi & convinci ceperint, ab eis qui nostrorum librorum auctoritate, & aperissima falsitate dixerunt, eosdem libros Sanctos, unde id probent, proferre conantur; vel etiam memoriter, quæ ad testimonium valere arbitrantur, multa inde verba pronunciant; non intelligentes, neque quæ loquuntur, neque de quibus affirmant.

(x) What trouble and sorrow weak undertakers bring upon their knowing Brethren, is not to be expressed; since when they begin to be told and convinced of their false and unsound Opinion, by those who have no respect for the Authority of our Scriptures, in defence of what through a fond Temerity, and most manifest falsity, they have urged; they fall to citing the said Sacred Books for proof of it, or else repeat many words by heart out of them, which they conceive to make for their purpose; not knowing either what they say, or whereof they affirm.

In the number of these we may, as I conceive, account those, who, being either unwilling or unable to understand the Demonstrations and Experiments, wherewith the Author and followers of this Opinion do confirm it, run upon all occasions to the Scriptures, not considering that the more they cite them, and the more they persist in affirming that they are very clear, and do admit no other senses, save those which they force upon them, the greater injury they do to the Dignity of them (if we allowed that their judgements were of any great Authority) in case that the Truth coming to be manifestly known to the contrary, should occasion any confusion, at least to those who are separated from the Holy Church; of whom yet she is very solicitous, and like a tender Mother, desirous to recover them again into her Lap. Your Highness therefore may see how præposterously those Persons proceed, who in Natural Disputations do range Texts of Scripture in the Front for their Arguments; and such Texts too many times, as are but superficially understood by them.

But if these men do verily think, & absolutely believe that they have the true sense of Such a particular place of Scripture, it must needs follow of consequence, that they do likewise hold for certain, that they have found the absolute truth of that Natural Conclusion, which they intend to dispute: And that withall, they do know that they have a great advantage of their Adversary, whose Lot it is to defend the part that is false; in regard that he who maintaineth the Truth, may have many sensible experiments, and many necessary Demonstrations on his side; whereas his Antagonist can make use of no other than deceitful appearances, *Paralogisms* and *Sophisms*. Now if they keeping within natural bounds, & producing no other Weapons but those of Philosophy, pretend however, to have so much advantage of their Enemy; why do they afterwards

wards in coming to engage, presently betake themselves to a Weapon inevitable & dreadful to terrifie their Opponent with the sole beholding of it? But if I may speak the truth, I believe that they are the first that are affrighted, and that perceiving themselves unable to bear up against the assaults of their Adversary, go about to find out ways how to keep them far enough off, forbidding unto them the use of the Reason which the Divine Bounty had vouchsafed them, & abusing the most equitable Authority of sacred Scripture, which rightly understood and applyed, can never, according to the common Maxime of Divines, oppose the Manifest Experiments, or Necessary Demonstrations. But these mens running to the Scriptures for a Cloak to their inability to comprehend, not to say resolve the Reasons alledged against them, ought (if I be not mistaken) to stand them in no stead: the Opinion which they oppose having never as yet been condemned by Holy Church. So that if they would proceed with Candor, they should either by silence confess themselves unable to handle such like points, or first consider that it is not in the power of them or others, but onely in that of the Pope, and of Sacred Councils to censure a Position to be Erroneous: But that it is left to their freedom to dispute concerning its falsity. And thereupon, knowing that it is impossible that a Proposition should at the same time be True and Heretical; they ought, I say, to employ themselves in that work which is most proper to them, namely, in demonstrating the falsity thereof: whereby they may see how needlesse the prohibiting of it is, its fallshood being once discovered, for that none would follow it: or the Prohibition would be safe, and without all danger of Scandal. Therefore first let these men apply themselves to examine the Arguments of *Copernicus* and others; and leave the condemning of them for Erroneous and Heretical to whom it belongeth: But yet let them not hope ever to finde such rash and precipitous Determinations in the Wary and Holy Fathers, or in the absolute Wisdom of him that cannot erre, as those into which they suffer themselves to be hurried by some particular Affection or Interest of their own. In these and such other Positions, which are not directly *de Fide*, certainly no man doubts but His Holiness hath alwayes an absolute power of Admitting or Condemning them, but it is not in the power of any Creature to make them to be true or false, otherwise than of their own nature, and *de facto* they are.

Therefore it is in my judgment more discretion to assure us first of the necessary and immutable Truth of the Fact, (over which none hath power) than without that certainty by condemning one part to deprive ones self of that authority of freedom

If this passage seem harsh, the Reader must remember that I do but Translate.

to elect, making those Determinations to become necessary, which at present are indifferent and arbitrary, and rest in the will of Supreme Authority. And in a word, if it be not possible that a Conclusion should be declared Heretical, whilst we are not certain, but that it may be true, their pains are in vain who pretend to condemn the Mobility of the Earth and Stability of the Sun, unless they have first demonstrated it to be impossible and false.

It remaineth now, that we consider whether it be true, that the Place in *Josuah* may be taken without altering the pure signification of the words: and how it can be that the Sun, obeying the command of *Josuah*, which was, *That it should stand still*, the day might thereupon be much lengthened. Which business, if the Celestial Motions be taken according to the *Ptolomaick* Systeme, can never any wayes happen, for that the Sun moving thorow the Ecliptick, according to the order of the Signes, which is from East to West (which is that which maketh Day and Night) it is a thing manifest, that the Sun ceasing its true and proper Motion, the day would become shorter and not longer; and that on the contrary, the way to lengthen it would be to hasten and velocitate the Suns motion; inlomuch that to cause the Sun to stay above the Horizon for some time, in one and the same place, without declining towards the West, it would be necessary to accelerate its motion in such a manner as that it might seem equal to that of the *Primum Mobile*, which would be an accelerating it about three hundred and sixty times more than ordinary. If therefore *Josuah* had had an intention that his words should be taken in their pure and proper signification, he would have bid the Sun to have accelerated its Motion so, that the Rapture of the *Primum Mobile* might not carry it to the West: but because his words were heard by people which hardly knew no other Celestial Motion, save the grand and common one, from East to West, stooping to their Capacity, and having no intention to teach them the Constitution of the Spheres, but only that they should perceive the greatness of the Miracle wrought, in the lengthening of the Day, he spoke according to their apprehension. Possibly this Consideration moved *Dionysius Areopagita* to say that in this Miracle the *Primum Mobile* stood still, and this stopping, all the Celestial Spheres did of consequence stay: of which opinion is *S. Augustine* himself, and *Abulensis* at large confirmeth it. Yea, that *Josuah's* intention was, that the whole Systeme of the Celestial Spheres should stand still, is collected from the command he gave at the same time to the Moon, although that it had nothing to do in the lengthening of the day; and under the injunction laid upon the Moon,

Moon, we are to understand the Orbes of all the other Planets; passed over in silence here, as also in all other places of the Sacred Scriptures; the intention of which, was not to teach us the Astronomical Sciences. I suppose therefore, (if I be not deceived) that it is very plain, that if we allow the *Ptolemaick* Systeme, we must of necessity interpret the words to some sense different from their strict signification. Which Interpretation (being admonished by the most usefull precepts of S. *Augustine*) I will not affirm to be of necessity this above-mentioned, since that some other man may haply think of some other more proper, and more agreeable Sense.

But now, if this same passage may be understood in the *Copernican* Systeme, to agree better with what we read in *Josuah*, with the help of another Observation by me newly shewen in the Body of the Sun; I will propound it to consideration, speaking alwaies with those safe Reserves; That I am not so affectionate to my own inventions, as to prefer them before those of other men, and to believe that better and more agreeable to the intention of the Sacred Volumes cannot be produced.

Supposing therefore in the first place, that in the Miracle of *Josuah*, the whole Systeme of the Celestial Revolutions stood still, according to the judgement of the afore-named Authors: And this is the rather to be admitted; to the end, that by the staying of one alone, all the Constitutions might not be confounded, and a great disorder needlessly introduced in the whole course of Nature: I come in the second place to consider how the Solar Body, although stable in one constant place, doth nevertheless revolve in it self, making an entire Conversion in the space of a Month, or thereabouts; as I conceive I have solidly demonstrated in my Letters *Delle Macchie Solari*: Which motion we sensibly see to be in the upper part of its Globe, inclined towards the South; and thence towards the lower part, to encline towards the North, just in the same manner as all the other Orbs of the Planets do. Thirdly, If we respect the Nobility of the Sun, and his being the Fountain of Light, by which, (as I necessarily demonstrate) not onely the Moon and Earth, but all the other Planets (all in the same manner dark of themselves) become illuminated; I conceive that it will be no unlogically illation to say, That it, as the Grand Minister of Nature, and in a certain sense the Soul and Heart of the World, infuseth into the other Bodies which environ it; not onely Light, but Motion also; by revolving * in it self: So that in the same manner that the motion of the Heart of an Animal ceasing; all the other motions of its Members would cease; so, the Conversion of the Sun ceasing, the Conversions of all the Planets would stand still. And though

* i. e. On its own Axis.

M m m

(*) *Lux quæ colligit, convertitque ad se omnia, quæ videntur, quæ moventur, quæ illustrantur, quæ calefcunt, & uno nomine ea, quæ ab ipsius splendore continentur. Itaque Sol hinc dicitur, quod omnia congregat, colligitque dispersa.*

(*) *Si enim Sol hic quem videmus, eorum quæ sub sensum cadunt, essentia & qualitates, quæque multa sunt ac distinctæ, tam in ipso qui unus est, æquiditerque lumen fundit, renovat, alit, tuetur, perficit, dividit, coniungit, fovet, facundia reddit, auget, mutat, firmat, educt, parat, vitalit, facit omnia: & unaquæque res huius universitatis, pro capite suo, unum æque eisdem Solis est participes, causasque multarum, quæ participant, in se æquibilibus anticipatas habet, certe majori ratione, &c.*

I could produce the testimonies of many grave Writers to prove the admirable power and influence of the Sun, I will content myself with one sole place of Holy *Dionysius Areopagita* in his Book *de Divinis Nominibus*; who thus writes of the Sun: (*) His Light gathereth and converteth all things to himself, which are seen, moved, illustrated, wax hot, and (in a word) those things which are preserved by his splendor: Wherefore the Sun is called *Hæc*, for that he collecteth and gathereth together all things dispersed. And a little after of the Sun again he adds; (*) If this Sun which we see, as touching the *Essences* and *Qualities* of those things which fall within our Sense, being very many and different; yet if he who is one, and equally bestowes his Light, doth renew, nourish, defend, perfect, divide, conjoyn, cherish, make fruitful, encrease, change, fix, produce, move, and fashion all living creatures: And every thing in this Universe at his Pleasure, is partaker of one and the same Sun; and the causes of many things which participate of him, are equally anticipated in him: Certainly by greater reason, &c. The Sun therefore being the Fountain of Light and Principle of Motion, God intending, that at the Command of *Josuah*, all the Worlds System, should continue many hours in the same state, it sufficeth to make the Sun stand still, upon whose stay (all the other Conversions ceasing) the Earth, the Moon, the Sun did abide in the same Constitution as before, as likewise all the other Planets: Nor in all that time did the Day decline towards Night, but it was miraculously prolonged: And in this manner, upon the standing still of the Sun, without altering, or in the least disturbing the other Aspects and mutual Positions of the Stars, the Day might be lengthned on Earth; which exactly agreeth with the Litteral sense of the Sacred Text.

But that of which, if I be not mistaken, we are to make no small account, is, That by help of this *Copernican Hypothesis*, we have the Litteral, apt, and Natural Sense of another particular that we read of in the same Miracle; which is, That the Sun stood still *in Medio Cali*: Upon which passage grave Divines raise many questions; in regard it seemeth very probable, That when *Josuah* desired the lengthning of the Day, the Sun was near setting, and not in the Meridian; for if it had been in the Meridian, it being then about the Summer Solstice, and consequently the dayes being at the longest, it doth not seem likely that it was necessary to pray for the lengthning of the day, to prosecute Victory in a Battail, the space of seven hours and more, which remained to Night, being sufficient for that purpose. Upon which Grave Divines have been induced to think that the Sun was near setting: And so the words themselves seem to sound

found, saying, *Ne movearis Sol, ne movearis.* For if it had been in the Meridian, either it had been needless to have asked a Miracle, or it would have been sufficient to have onely praid for some retardment. Of this opinion is *Cajetan*, to which subscribeth *Magaglianes*, confirming it by saying, that *Josbua* had that very day done so many other things before his commanding the Sun, as were not possibly to be dispatch't in half a day. Whereupon they are forced to read the Words in *Medio Cali* (to confess the truth) with a little harshness, saying that they import no more than this: *That the Sun stood still, being in our Hemisphere, that is, above the Horizon.* But (if I do not erre) we shall avoid that and all other harsh expositions, if according to the *Copernican* Systeme we place the Sun in the midst, that is, in the Centre of the Cœlestial Orbes, and of the Planetary Conversions, as it is most requisite to do. For supposing any hour of the day (either Noon, or any other, as you shall please neerer to the Evening) the Day was lengthened, and all the Cœlestial Revolutions stayed by the Suns standing still, *In the midst*, that is, *in the Centre of Heaven*, where it resides: A Sense so much the more accomodate to the Letter (besides what hath been said already) in that, if the Text had desired to have affirmed the Suns Rest to have been caused at Noon-day, the proper expression of it had been to say, *It stood still at Noon-day*, or *in the Meridian Circle*, and not *in the midst of Heaven*: In regard that the true and only Middle of a Spherical Body (as is Heaven) is the Centre.

Again, as to other places of Scripture, which seem contrary to this position, I do not doubt but that if it were acknowledged for True and Demonstrated those very Divines who so long as they repùte it false, hold those places incapable of Expositions that agree with it would finde such Interpretations for them, as should very well suit therewith; and especially if to the knowledge of Divine Learning they would but adde some knowledge of the Astronomical Sciences: And as at present, whilst they deem it false they think they meet in Scripture only with such places as make against it, if they shall but once have entertained another concept thereof, they would meet peradventure as many others that accord with it, and haply would judge, that the Holy Church doth very appositly teach, That God placed the Sun in the Centre of Heaven, and that thereupon by revolving it in it self, after the manner of a Wheel, He contributed the ordinary Courses to the Moon and other Erratick Stars, whilst that she Sings,

*Cali Deus sanctissime,
Qui lucidum Centrum Poli,*
M m m 2

Candore

*Solem stetit,
dum adhuc in Hemisphaerio nostro,
supra scilicet Horizonem existeret.
Cajetan in loco.*

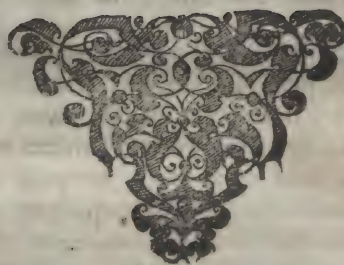
The Authority of SCRIPTURE

Candore pingis igneo,
 Augens decoro lumine,
 Quarto die, qui flammeam
 Solis rotam constituens
 Luna ministras ordinem,
 Vagosque cursus Syderum.

They might say, that the Name of *Firmament* very well agreeth, *ad litteram*, to the Starry Sphere, and to all that which is above the Planetary Conversions; which according to this Hypothesis is altogether *firme* and immoveable. *Ad litteram* (the Earth moving circularly) they might understand its *Poles*, where it's said, *Nec dum Terram fecerat, & flumina, & Cardines Orbis Terræ*, Which *Cardines* or * *Hinges* seem to be ascribed to the Earth in vain, if it be not to turn upon them.

* Or Poles.

FINIS.



AN
ABSTRACT

OF THE

Learned Treatise

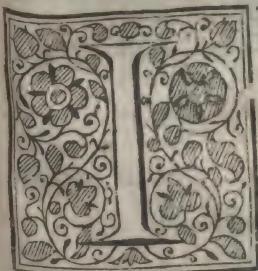
OF

JOHANNIS KEPLERUS,

The Emperours *Mathematician*:

ENTITULED

His Introduction upon MARS:



LT must be confessed, that there are very many who are devoted to Holinesse, that dissent from the Judgment of *Copernicus*, fearing to give the Lye to the Holy Ghost speaking in the Scriptures, if they should say, that the Earth moveth, and the Sun stands still. But let such consider, that since we judge of very many, and those the most principal things by the Sense of Seeing, it is impossible that we should alienate our Speech from this Sense of our Eyes. Therefore many things daily occur, of which we speak according to the Sense of Sight, when as we certainly know that the things themselves are otherwise. An Example whereof we have in that Verse of *Virgil*;

Provehimur portu, Terræque urbisque recedunt.

So when we come forth of the narrow straight of some Valley, we say that a large Field discovereth it self. So Christ to *Peter*, *Duc in altum*; [Lanch forth into the Deep, or on high,] as if the Sea were higher than its Shores; For so it seemeth to the Eye, but the Opticks shew the cause of this fallacy. Yet Christ useth the most received Speech, although it proceed from this delusion of the Eyes. Thus we conceive of the Rising and
 Setting

Setting of the Stars, that is to say, of their Ascension and Descension; when at the same time that we affirm the Sun riseth, others say, that it goeth down. See my *Optices Astronomie*, cap. 10. fol. 327. So in like manner, the *Ptolomaicks* affirm, that the Planets stand still, when for some dayes together they seem to be fixed, although they believe them at that very time to be moved in a direct line, either downwards to, or upwards from the Earth. Thus the Writers of all Nations use the word *Solstitium*, and yet they deny that the Sun doth really stand still. Likewise there will never any man be so devoted to *Copernicus*, but he will say, the Sun entereth into *Cancer* and *Leo*, although he granteth that the Earth enters *Capricorn* or *Aquarius*: And so in other cases of the like nature. But now the Sacred Scriptures, speaking to men of vulgar matters (in which they were not intended to instruct men) after the manner of men, that so they might be understood by men, do use such Expressions as are granted by all, thereby to insinuate other things more Mysterious and Divine. What wonder is it then, if the Scripture speaks according to mans apprehension, at such time when the Truth of things doth dissent from the Conception that all men, whether Learned or Unlearned have of them? Who knows not that it is a Poetical allusion, *Psal.* 19. where, whilst under the similitude of the Sun, the Course of the Gospel, as also the Peregrination of our Lord Christ in this World, undertaken for our sakes, is described, *The Sun is said to come forth of his Tabernacle of the Horizon, as a Bridegroom out of his Chamber, rejoicing as a Giant to run a Race?* Which *Virgil* thus imitates;

Tithono crocenm linquens Aurora cubile :

For the first Poets were amongst the Jews. The Psalmist knew that the Sun went not forth of the Horizon, as out of its Tabernacle; & yet it seemeth to the Eye so to do: Nor did he believe, that the Sun moved, for that it appeared to his sight so to do. And yet he saith both, for that both were so to his seeming. Neither is it to be adjudged false in either Sense: for the perception of the Eyes hath its verity, fit for the more secret purpose of the Psalmist in shadowing forth the current passage of the Gospel, as also the Peregrination of the Son of God. *Joshua* likewise mentioneth the Vallies on or in, which the Sun and Moon moved, for that they appeared to him at *Jordan* so to do: And yet both these Pen-men may obtain their ends. *David*, (and with him *Syracides*) the magnificence of God being made known, which caused these things to be in this manner represented to sight, or otherwise, the mystical meaning, by means of these Visibles being discerned: And *Joshua*, in that the Sun, as to his Sense

Sense of Seeing, staid a whole day in the midst of Heaven, where-
as at the same time to others it lay hid under the Earth. But in-
cogitant persons onely look upon the contrariety of the words;
The Sun stood still, that is, *The Earth stood still*; not considering
that this contradiction is confined within the limits of the Op-
ticks and Astronomy: For which cause it is not outwardly ex-
posed to the notice and use of men: Nor will they understand
that the onely thing *Josuah* prayed for, was that the Mountains
might not intercept the Sun from him; which request he expres-
sed in words, that suited with his Ocular Sense: Besides it had
been very unseasonable at that time to think of Astronomy, or
the Errours in Sight; for if any one should have told him that
the Sun could not really move upon the Valley of *Ajalon*, but
onely in relation to Sense, would not *Josuah* have replied, that
his desire was that the day might be prolonged, so it were by
any means whatsoever? In like manner would he have answered
if any one had started a question about the Suns Mobility, and
the Earths Motion. But God easily understood by *Josuahs*
words what he asked for, and by arresting the Earths Motion,
made the Sun in his apprehension seem to stand still. For the
sum of *Josuahs* Prayer amounts to no more but this, that it
might thus appear to him, let it in the mean time be what it
would of it self. For that its so seeming, was not in vain and
ridiculous, but accompanied with the desired effect. But read
the tenth Chap. of my Book, that treats of the Optick part of A-
stronomy, where thou shalt finde the Reasons why the Sun doth
in this manner seem to all mens thinking to be moved, and not
the Earth; as namely, because the Sun appeareth small, and the
Earth bigg. Again, the Motion of the Sun is not discerned by
the eye, by reason of his seeming tardity, but by ratiocina-
tion onely; in that after some time it varieth not its proximity to
such and such Mountains. Therefore it is impossible that Rea-
son, unless it be first instructed, should frame to it self any other
apprehension, than that the Earth with Heavens Arch placed
over it, is as it were a great House, in which, being immoveable,
the Sun like a Bird flying in the Air, passeth in so small a Species
out of one Climate into another. Which imagination of all
Man-kinde being thus, gave the first line in the Sacred Leaves:
In the beginning (saith Moses) God created the Heaven and the
Earth; for that these two are most obvious to the eye. As if
Moses should have said thus to Man; This whole Mundane Fa-
brick which thou seest, lucid above, and dark, and of a vast ex-
tent beneath, wherein thou hast thy being, and with which thou
art covered, was created by God.

In another place Man is questioned; *Whether he can finde out*
the

* Gen. Chp. 1.
v. 1.

*the height of Heaven above, or depth of the Earth beneath: for that each of them appeareth to men of ordinary capacity, to have equally an infinite extent. And yet no man that is in his right mind will by these words circumscribe and bound the diligence of Astronomers, whether in demonstrating the most contemptible Minuities of the Earth, in comparison of Heaven, or in searching out Astronomical Distances: Since those words speak not of the Rational, but real Dimension; which to a Humane Body, whilst confin'd to the Earth, and breathing in the open Air, is altogether impossible. Read the whole 38. Chapter of Job, and compare it with those Points which are disputed in Astronomy, and Physiologic. If any one do alledge from Psal. 24. That * The Earth is founded upon the Seas, to the end that he may thence infer some new Principle in Philosophy, absurd to hear; as, That the Earth doth float upon the Waters; may it not truly be told him, That he ought not to meddle with the Holy Spirit, nor to bring him with contempt into the School of Physiologic. For the Psalmist in that place means nothing else but that which men fore-know, and daily see by experience; namely, That the Earth (being lifted up after the separation of the Waters) doth swim between the Grand Oceans, and float about the Sea. Nor is it strange that the expression should be the same where the Israelites sing, * That they sate on the River of Babylon; that is, by the River side. or on the Banks of Euphrates and Tigris.*

* Psal. 24. 2.

Psal. 137. 7.

* Chap. iiv. 4, 5, 6, 7, 8, 9.

If any one receive this Reading without scruple, why not the other; that so in those same Texts which are wont to be alledged against the Motion of the Earth, we may in like manner turn our eyes from Natural Philosophy, to the scope and intent of Scripture. *One Generation passeth away, (saith Ecclesiastes) and another Generation cometh: But the Earth abideth for ever.* * As if Solomon did here dispute with Astronomers, and not rather put men in minde of their Mutability; whereas the Earth, Mankinds habitation, doth alwaies remain the same: The Suns Motion doth continually return into what it was at first: The Wind is acted in a Circle, and returns in the same manner: The Rivers flow from their Fountains into the Sea, and return again from thence unto their Fountains: To conclude, The Men of this Age dying, others are born in their room; the Fable of Life is ever the same; there is nothing new under the Sun. Here is no reference to any Physical Opinion. *Nothing is Moral of a thing in it self manifest, and seen by the eyes of all, but little regarded: Tis that therefore which Solomon doth inculcate.* For who knows not that the Earth is alwaies the same? Who sees not that the Sun doth arise from the East; That the Rivers continually run into the

the Sea ; That the vicissitudes of the Windes return into their primitive State ; That some men succeed others ? But who considereth that the self-same *Scene* of Life is ever acting, by different persons ; and that nothing is *new* in humane affairs ? Therefore *Solomon* instancing in those things which all men see, doth put men in minde of that which many thorowly know, but too slightly consider.

But the 104. *Psalme* is thought by some to contain a Discourse altogether Physical, in regard it onely concerns Natural Philosophy. Now God is there said, *To have laid the Foundations of the Earth, that it should not be removed for ever.* But here also the Psalmist is far from the Speculation of Physical Causes : For he doth wholly acquiesce in the Greatnesse of God, who did all these things, and sings an Hymne to God the Maker of them, in which he runneth over the World in order, as it appeared to his eyes. And if you well consider this Psalm, it is a Paraphrase upon the six dayes work of the Creation : For as in it the three first dayes were spent in the Separation of Regions ; the first of Light from the exterior Darknes ; the second, of the Waters from the Waters, by the interposition of the Firmament ; the third, of the Sea from Land ; when also the Earth was cloathed with Herbage and Plants : And the three last dayes were spent in the filling the Regions thus distinguished ; the fourth, of Heaven ; the fifth, of the Seas and Aire ; the sixth, of the Earth : So here in this Psalm there are so many distinct parts proportionable to the Analogy of the six dayes Works. For in *Verse 2.* he cloaths and covereth the Creator with Light (the first of Creatures, and work of the first day) as with a Garment. The second part beginneth at *Verse 3.* and treats of the Waters above the Heavens, the extent of Heaven and of Meteors (which the Psalmist seemeth to intend by the Waters above) as namely of Clouds, Winds, Whirl-winds, Lightnings. The third part begins at *Verse 6.* and doth celebrate the Earth as the foundation of all those things which he here considereth. For he referreth all things to the Earth, and to those Animals which inhabit it, for that in the judgment of Sight the two principal parts of the World are Heaven and Earth. He therefore here observeth that the Earth after so many Ages hath not faltered, tired, or decayed ; when as notwithstanding no man hath yet discovered upon what it is founded. He goeth not about to teach men what they do not know, but putteth them in minde of what they neglect, to wit, the Greatnesse and Power of God in creating so huge a Mass so firm and stedfast. If an Astronomer should teach that the Earth is placed among the Planets, he

Psal. 104. v. 5.

N n n

over-

* Shelter.

overthroweth not what the Psalmist here saith, nor doth he contradict Common Experience; for it is true notwithstanding, that the Earth, the Structure of God its Architect, doth not decay (as our Buildings are wont to do) by age, or consume by wormes, nor sway and leane to this or that side; that the Seats and Nests of Living Creatures are not molested; that the Mountains and Shores stand immoveable against the violence of the Winds and Waves, as they were at the beginning. But the Psalmist addeth a most Elegant Hypothesis of the Separation of the Waters from the Continent or Main-land, and adorns it with the production of Fountains, and the benefits that Springs and Rocks exhibit to Birds and Beasts. Nor doth he omit the apprelling the Earths Surface, mentioned by *Moses* amongst the works of the third Day, but more sublimely describeth it in his Case in expressions infused from Divine Inspiration; and flourisheth out the commemoration of the many commodities which redound from that Exornation for the Nourishment and Comfort of Man, and * Covert of Beasts. The fourth part begins at *Verse 20.* celebrating the fourth dayes work, viz. The Sun and Moon, but chiefly the commodiousnesse of those things, which in their Seasons befall to all Living Creatures and to Man; this being the subject matter of his Discourse: So that it plainly appeareth he acted not the part of an Astronomer. For if he had, he would not then have omitted to mention the five Planets, than whose moiton nothing is more admirable, nothing more excellent, nothing that can more evidently set forth the Wisdome of the Creator amongst the Learned. The fifth part begins, *Verse 25.* with the fifth Dayes work. And it stores the Seas with Fishes, and covers them with Ships. The sixth part is more obscurely hinted at, *Verse 28.* and alludeth to the Land-Creatures that were created the sixth day. And lastly, he declareth the goodnesse of God in general, who daily createth and preserveth all things? So that whatever he said of the World is in relation to Living Creatures; He speaks of nothing but what is granted on all hands; for that it was his intent to extol things known, and not to dive into hidden matters, but to invite men to contemplate the Benefits that redound unto them from the works of each of these dayes.

And I do also beseech my Reader, not forgetting the Divine Goodnesse conferred on Mankind; the consideration of which the Psalmist doth chiefly urge, that when he returneth from the Temple, and enters into the School of *Astronomy*, he would with me praise and admire the Wisdome and Greatnesse of the Creator, which I discover to him by a more narrow explication of the Worlds Form, the Disquisition of Causes, and Detection of

of the Errours of Sight : And so he will not onely extoll the Bounty of God in the preservation of Living Creatures of all kindes, and establishment of the Earth ; but even in its Motion also, which is so strange, so admirable, he will acknowledge the Wildome of the Creator. But he who is so stupid as not to comprehend the Science of *Astronomy*, or so weak and scrupulous as to think it an offence of Piety to adhere to *Copernicus*, him I advise, that leaving the Study of *Astronomy*, and censuring the opinions of Philosophers at pleasure, he betake himself to his own concerns, and that desisting from further pursuit of these intricate Studies, he keep at home and manure his own Ground ; and with those Eyes wherewith alone he seeth, being elevated towards this to be admired Heaven ; let him pour forth his whole heart in thanks and praises to God the Creator ; and assure himself that he shall therein perform as much Worship to God, as the *Astronomer*, on whom God hath bestowed this Gift, that though he seeth more clearly with the Eye of his Understanding ; yet whatever he hath attained to, he is both able and willing to extoll his God above it.

And thus much concerning the Authority of Sacred Scripture. Now as touching the opinions of the Saints about these Natural Points. I answer in one word, That in Theology the weight of Authority, but in Philosophy the weight of Reason is to be considered. Therefore Sacred was *Lactantius*, who denied the Earths rotundity ; Sacred was *Augustine*, who granted the Earth to be round, but denied the *Antipodes* ; Sacred is the *Liturgy of our Moderns, who admit the smallnesse of the Earth, but deny its Motion : But to me more sacred than all these is Truth, who with respect to the Doctors of the Church, do demonstrate from Philosophy that the Earth is both round, circumhabited by *Antipodes*, of a most contemptible smalnesse, and in a word, that it is ranked amongst the Planets.

* Officiarius

Nnn 2

AN

AN ABSTRACT OF

Some passages in the Commentaries of

Didacus à Stunica,

OF SALAMANCA

Upon *JOB*:

The Toledo Edition, Printed by *JOHN RODERICK*,
Anno 1584, in *Quarto*, Pag. 205. & seqq. on
these Words, Chap. 9. Verse 6.

*Who shaketh the Earth out of her place, and the Pil-
lars thereof Tremble.*



The Sacred Pen-man here sets down another ef-
fect whereby God sheweth his Almighty Pow-
er, joyned with infinite Wisdom. Which
place, though it must be confessed very diffi-
cult to understand, might be greatly cleared
by the Opinion of the *Pythagorians*, who
hold the Earth to be moved of its own Na-
ture, and that the Motion of the Stars can no other way be ascer-
tained, they being so extreemly different in tardity and velocity.
Of which judgement was *Philolaus*, and *Heraclides Ponticus*, as
Plutarch relateth in his Book *De Placitis Philosophorum*: Who
were followed by *Numa Pompilius*, and, which I more regard,
The Divine *Plato* in his old age; insomuch that he affirmed that
it was most absurd to think otherwise, as the same *Plutarch* tells
us in his * *Numa*. And *Hypocrates* in his Book *De Flatibus*,
calleth the Air *πνεῦμα*, i. e. The Earths Chariot. But in this
our

* *In vita ejus.*

our Age, *Copernicus* doth demonstrate the courses of the Planets to be according to this Opinion. Nor is it to be doubted but that the Planets Places may be more exactly and certainly assigned by his Doctrine, than by *Ptolomies* Great Almogest or Systeme, or the Opinions of any others. For its manifest, that *Ptolomy* could never describe either the Motion of the Equinoxes, or assign the certain and positive beginning of the Year: the which he ingeniously confesseth in *Lib. 3. De Almagest. Magnum. Ch. 2.* and which he leaveth to be discovered in after times by those Astronomers, who coming into the World much later than he, might be able to invent some way to make more accurate observations. And although the * *Alphonfines & Thebith Ben Core* have attempted to explain them; yet it appeareth that they have done as much as nothing. For the Positions of the *Alphonfines* disagree amongst themselves, as *Ricinus* proverth. And although the Reason of *Thebith* be more acute, and that thereby he determined the certain beginning of the year, (being that which *Ptolomy* sought for) yet it is now clear, that the Progressions of the Equinoxes are much longer than he conceived they could be. Moreover, the Sun is found to be much nearer to us than it was held to be in times past, by above fourty thousand * *Stadia*, or furlongs. The Cause and Reason of whose Motion; neither *Ptolomy* nor any other Astrologers could ever comprehend: And yet the Reasons of these things are most plainly explained and demonstrated by *Copernicus* from the Motion of the Earth, with which he sheweth that all the other *Phænomena* of the Universe do more aptly accord. Which opinion of his is not in the least contradicted by what *Solomon* saith in * *Ecclesiastes*: But the Earth abideth for ever. For that Text signifieth no more but this, That although the succession of Ages, and generations of Men on Earth, be various; yet the Earth it self is still one and the same, and continueth without any sensible alteration; For the words run thus: One Generation passeth away, and another Generation cometh; but the Earth abideth for ever. So that it hath no coherence with its Context, (as Philosophers shew) if it be expounded to speak of the Earths immobility. And although in this Chapter *Ecclesiastes*, and in many others, Holy Writ ascribes Motion to the Sun, which *Copernicus* will have to stand fixed in the Centre of the Universe; yet it makes nothing against his Position. For the Motion that belongs to the Earth, is by way of speech assigned to the Sun, even by *Copernicus* himself, and those who are his followers, so that the Revolution of the Earth is often by them phrased, The Revolution of the Sun. To conclude, No place can be produced out of Holy Scripture, which so clearly speaks the Earths Immobility, as this doth its

* Followers of that Learned Kings Hypothesis.

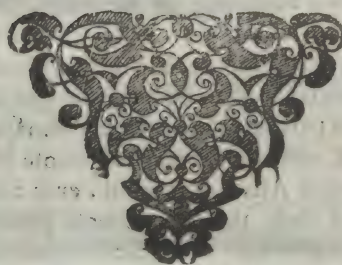
* That is 5000 miles; eight of these making an Italian, or English mile of a 1000. paces every pace containing 5. Feet.

* Chap. I. v. 4.

The Motion of the Earth, not against Scripture.

Mo-

Mobility. Therefore this Text, of which we have spoken, is easily reconciled to this Opinion. And to set forth the Wonderful power and Wisdom of God, who can indue and actuate the Frame of the Whole Earth (it being of a monstrous weight by Nature) with Motion, this our Divine pen-man addeth; *And the pillars thereof tremble*: As if he would teach us, from the Doctrine laid down, that it is moved from its Foundations.



AN
EPISTLE

Of the Reverend Father

PAOLO ANTONIO FOSCARINI,
A CARMELITE;

Concerning

The PYTHAGORIAN and COPERNICAN Opinion
OF

The Mobility of the EARTH,

AND

Stability of the SUN;

AND

Of the New Systeme or Constitution
OF THE

WORLD.

IN WHICH,

The Authorities of SACRED SCRIPTURE,
and ASSERTIONS of DIVINES,
commonly alledged against this Opinion,
are Reconciled.

WRITTEN

To the most Reverend FATHER,
SEBASTIANO FANTONI,
General of the Order of CARMELITES.

Englisht from the Original,
BY

THOMAS SALUSBURIE.

*Se quis indiget sapientia, postulet
à Deo. Jacobi 1. versu. 5.
Oravi, & datus est mihi sensus.
Sapientiae 7. versu. 7.*

LONDON,

Printed by WILLIAM LEYBOURN, MDCLXI.

EPISTLE

TO THE HONORABLE THE LORDS OF THE COMMONS OF GREAT BRITAIN

IN PARLIAMENT ASSEMBLED

THE PETITION OF THE

SENATORS OF THE UNIVERSITY OF CAMBRIDGE

SHUNTHAT THEY MAY BE ALLOWED TO PRESENT

THEIR PETITION

IN WITNESS WHEREOF THEY HAVE SUBSCRIBED THEIR NAMES

TO THE PETITION OF THE SENATORS OF THE UNIVERSITY OF CAMBRIDGE

IN WITNESS WHEREOF THEY HAVE SUBSCRIBED THEIR NAMES

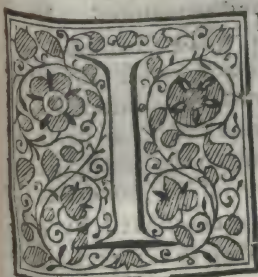
TO THE PETITION OF THE SENATORS OF THE UNIVERSITY OF CAMBRIDGE

18



der
ney
laid
an
go
wi
fo
So
in
m
no
in
c
w
fe
p
c
n
f
f

To the Most
 Reverend Father
 SEBASTIANO FANTONI,
 General of the Order of
 CARMELITES.



N obedience to the command of the Noble Signore *Vincenzo Carraffa*, a Neapolitan, and Knight of *S. John of Jerusalem*, (a person, to speak the truth, of so great Merit, that in him Nobility of Birth, Affability of Manners, Universal knowledge of Arts and things, Piety and Vertue do all contend for preheminence) I resolved with my self to undertake the Defence of the Writings of the New, or rather Renewed, and from the Dust of Oblivion (in which it hath long lain hid) lately Revived Opinion, *Of the Mobility of the Earth, and Stability of the Sun*, in times past found out first by *Pythagoras*, and at last reduced into Practice by *Copernicus*; who likewise hath deduced the Position of the Systeme and Constitution of the World and its parts from that Hypothesis: on which Subject I have formerly writ to You, Most Reverend Sir: But in regard I am bound for *Rome* to preach there by your Command; and since this Speculation may seem more proper for another Treatise, to wit, a Volume of *Cosmography*, which I am in hand with, and which I am daily busie about, that it may come forth in company with my *Compendium of the Liberal Arts*, which I have already finished, rather than now to discuss it by it self, I thought to forbear, imparting what I have done for the present; Yet I was desirous to give, in the mean time, a brief account of this my Determination, and to shew You, Most Reverend Father, (to whom I owe all my indeavours, and my very self) the Foundations on which this Opinion may be grounded, least, whilst otherwise it is favoured with much probability, it be found in reality to be extreemly repugnant (as at first sight it seems)

O o o

The Authority of SCRIPTURE

seems) not onely to Physical Reasons, and Common Principles received on all hands (which cannot do so much harm) but also (which would be of far worse consequence) to many Authorities of sacred Scripture : Upon which account many at their first looking into it, explode it as the most fond Paradox and Monstrous *Capriccio* that ever was heard of. Which thing proceeds only from an antiquated and long confirmed Custome, which hath so hardened men in, and habituated them to Vulgar, Plausible, and for that cause by all men (as well learned as unlearned) Approved Opinions, that they cannot be removed one step from them : So great is the force of Custome (which not unfitly is stiled a second Nature) prevailing over the whole World, that touching things men are rather pleased with, delighted in, and desirous of those, which, though evil and obnoxious, are by use made familiar to them, than such, wherewith, though better, they are not accustomed and acquainted. So in like manner, and that chiefly, in *Opinions*, which when once they are rooted in the Mind, men start at, and reject all others whatsoever ; not only those that are contrary to, but even all that ever so little disagree with or vary from theirs, as harsh to the Ear, discoloured to the Eye, unpleasant to the Smell, nauseous to the Taste, rough to the Touch. And no wonder : For Physical Truths are ordinarily judged and considered by men, not according to their Essence, but according to the prescript of some one whose description or definition of them gains him Authority amongst the vulgar. Which authority nevertheless (since 'tis no more than humane) ought not to be so esteemed, as that that which doth manifestly appear to the contrary, whether from better Reasons lately found out, or from Sense it self, should for its sake be contemned and slighted ; Nor is Posterity so to be confined, but that it may, and dares, not only proceed farther, but also bring to light better and truer Experiments than those which have been delivered to us by the Ancients. For the *Genius* of the Antients, as in Inventions they did not much surpass the Wits of our times ; so for the perfecting of Inventions this Age of ours seems not only to equal, but far to excell former Ages ; Knowledge, whether in the Liberal or Mechanical Arts, daily growing to a greater height. Which Assertion might be easily proved, were it not that in so clear a case, there would be more danger of obscuring, than hopes of illustrating it with any farther light.

But (that I may not wholly be silent in this point) have not the several Experiments of Moderns, in many things, stopped the mouth of Venerable Antiquity, and proved many of their greatest and weightiest Opinions, to be vain and false? The Doctrine
of

of the *Antipodes* by many of the Antients of approved Wisdom and Learning was held a Paradox no less absurd than this Our Opinion of the *Earth's Motion* may seem to be; as likewise that of the *Habitableness of the Torrid Zone*: Of these Opinions, the first was accounted impossible by many, but the latter was absolutely denied by the unanimous consent of all: But later Authors (to the great felicity and perpetual Glory of their Age) have, not so much by Authority, as by accurate diligence and indefatigable study to find out the truth, proved them both to be undoubtedly true. Thus I affirm that the Antients were deceived, and that in too lightly challenging Credit and Authority for their Inventions, they discovered too much folly. Here for brevities sake I pass by many Dreams lately detected, both of *Aristotle* and other of the antient Philosophers; who in all likelihood if they had dived into the Observations of Modern Writers, and understood their Reasons, would, by changing their Judgements, have given them the precedency, and would have subscribed to their manifest Truth. Hereby we see that we are not to have so high a respect for the Antients, that whatever they assert should be taken upon trust, and that Faith should be given to their sayings, as if they were Oracles and Truths sent down from Heaven. But yet (which indeed is chiefly to be regarded in these matters) if any thing be found out that is repugnant to Divine Authority, or to the Sacred Leaves, that were dictated by the Holy Ghost, and by His Inspiration expounded by the Holy Doctors of the Church, in this case not only Humane Reason, but even Sense it self is to submit: which, though by all manner of weighty Conditions and circumstances it should hold forth any thing contrary to Divine Authority, (which indeed is so plain, that there is no way left to evade the right understanding of it) yet is it to be rejected; and we must conclude our selves deceived by it, and believe that that is not true which Sense and Reason represents unto us: For, however we judge of things, we have, both in this and all other cases, a more certain knowledge, which proceeds from Divine Faith; as *S. Peter* hath most excellently expressed it: Who though with his Senses he saw, and perceived the Glory of our Lord in his Transfiguration, and heard his words manifesting his great Power; yet nevertheless all these things compared with the Light of Faith, he adds: **We have also a more sure word of Prophecy, &c.* Wherefore since this Opinion of *Pythagoras* and *Copernicus* hath entred upon the Stage of the World in so strange a Dress, and at the first appearance (besides the rest) doth seem to oppose sundry Authorities of Sacred Scripture, it hath (this being granted) been justly rejected of all men as a meer absurdity.

O o o 2

But

Faith is more certain, than either Sense or Reason.

2 Pet. i. 19.

But yet because the common Systeme of the World devised by *Ptolemy* hath hitherto satisfied none of the Learned, hereupon a suspicion is risen up amongst all, even *Ptolemy's* followers themselves, that there must be some other Systeme, which is more true than this of *Ptolemy*; For although the *Phænomena* of Celestial Bodies may seem to be generally resolved by this Hypothesis, yet they are found to be involved with many difficulties, and referred to many devices; as namely, of Orbes of sundry Forms and Figures, Epicycles, Equations, Differences, Excentricks, and innumerable such like fancies and Chymara's which savour of the *Ens Rationis* of Logicians, rather than of any *Realem Essentiam*. Of which kinde is that of the *Rapid Motion*, than which I finde not any thing that can be more weakly grounded, and more easily controverted and disproved: And such is that conceit of the * Heaven void of Stars, moving the inferior Heavens or Orbes: All which are introduced upon occasion of the variety of the Motions of Celestial Bodies, which seemed impossible; by any other way, to be reduced to any certain and determinate Rule. So that the Assertors of that common Opinion, freely confess, that in describing the Worlds Systeme, they cannot as yet discover, or teach the true Hypothesis thereof: But that their endeavours are onely to finde out, amongst many things, what is most agreeable with truth, and may, upon better and more accomodate Reasons, answer the Celestial *Phænomena*.

Since that, the Telescope (an Optrick Invention) hath been found out, by help of which, many remarkable things in the Heavens, most worthy to be known, and till then unthought of, were discovered by manifest sensation; as for instance, That the Moon is Mountainous; *Venus* and *Saturn* Tricorporeal; and *Jupiter* Quadricorporeal: Likewise that in the *Via Lactea*, in the *Pleiades*, and in the Stars called *Nublosæ* there are many Stars, and those of the greatest Magnitude which are by turns adjacent to one another; and in the end it hath discovered to us, new fixed Stars, new planets, and new Worlds. And by this same Instrument it appears very probable, that *Venus* and *Mercury* do not move properly about the Earth, but rather about the Sun; and that the Moon alone moveth about the Earth. What therefore can be inferred from hence, but that the Sun doth stand immovable in the Centre, and that the Earth, with the other Celestial Orbes, is circumvolved about it? Wherefore by this and many other Reasons it appears, That the Opinion of *Pythagoras* and *Copernicus* doth not disagree with Astronomical and Cosmographical Principles; yea, that it carryeth with it a great likelihood and probability of Truth: Whereas amongst the so many several Opinions, that deviate from the common Systeme, and devile others,

* O^o *Primum*
Alabaz.

others, such as were those of *Plato*, *Calippus*, *Endoxus*; and since them of *Averroes*, * *Cardanus*, *Fracastorius*, and others both Antient and Modern, there is not one found that is more facile, more regularly and determinately, accommodated to the *Phænomena* and Motions of the Heavens, without *Epicycles*, *Excentrix*, *Homocentrick*, *Deferents*, and the supputation of the Rapid Motion. And this Hypothesis hath been asserted for true, not onely by *Pythagoras*, and, after him, by *Copernicus*, but by many famous men, as namely, *Heraclitus*, and *Euphantus*, *Pythagoreans*, all the Disciples of that Sect, *Miceta* of *Syracuse*, *Martianus Capella*, and many more. Amongst whom, those (as we have said) that have attempted the finding out of New Systemes (for they refused both this of *Pythagoras*, and that of *Ptolemy*) are numberless: who yet notwithstanding allowed this Opinion of *Pythagoras* to carry with it much probability, and indirectly confirmed it; inasmuch as that they rejected the common one as imperfect, defective, and attended with many contradictions and difficulties. Amongst these may be numbered Father * *Clavius*, a most learned Jesuite; who, although he refutes the Systeme of *Pythagoras*, yet acknowledgeth the Levity of the common Systeme, and he ingeniously confesseth, that for the removal of difficulties, in which the common Systeme will not serve the turn, Astronomers are forced to enquire after another Systeme, to the discovery of which, he doth very earnestly exhort them.

Now can there a better or more commodious Hypothesis be devised, than this of *Copernicus*? For this Cause many Modern Authors are induced to approve of, and follow it: but with much hesitancy, and fear, in regard that it seemeth in their Opinion so to contradict the Holy Scriptures, as that it cannot possibly be reconciled to them. Which is the Reason that this Opinion hath been long suppressed, and is now entertained by men in a modest manner, as if it were with a veiled Face; according to that advice of the Poet:

*Judicium populi nunquam contempseris unus,
Ne nullis placeas, dum vis contemnere multos.*

Upon consideration of which, (out of my very great love towards the Sciences, and my ardent desire to see the increase and perfection of them, and the Light of Truth freed from all Errors and Obscurities) I began to argue with my self touching this Point after this manner: This Opinion of the *Pythagoreans* is either true, or false; If false, it ought not to be mentioned, and deserves not to be divulged: If true, it matters not, though it contradict all, as well Philosophers as Astronomers: And though for its establishment and reducement to use a new Philosophy

* *Cardanus de rebus mathematicis. Lib. I. Cap. 1.*

* *P. Clavius in ultima suor. Operum editione.*

and Astronomy, (founded upon new Principles and Hypothese) should be constituted: For the Authority of Sacred Scripture will not oppose it; neither doth one Truth contradict another. If therefore the Opinion of *Pythagoras* be true, without doubt God hath disposed and dictated the words of of Holy Writ in such a manner, that they may admit an apt sense and reconciliation with that Hypothesis. Being moved by these Reasons, and the probability of the said Opinion, I thought good to try whether Texts of Sacred Scripture might be expounded according to Theological and Physical Principles, and might be reconciled to it, so that (in regard that hitherto it hath been held probable) it may in after times, coming without scruple to be acknowledged for true, advance it self, and appear in publick with an uncovered Face, without any mans prohibition, and may lawfully and freely hold a Sacred intelligence with Holy Truth, so earnestly coveted and commended by good Men. Which designe, having hitherto been undertaken by none that I know, wil, I am perswaded, be very acceptable to the Studios of these Learnings, especially to the most Learned *Galileo Galilei*, chief Mathematician to the most Serene Grand Duke of *Tuscany*, and *John Kepler*, chief Mathematician to his Sacred and invincible Majesty, the Emperour, and to all that Illustrious, and much to be commended Academy of the *Lyceans*; whom, if I mistake not, are all of this Opinion. Although I doubt not but they, and many other Learned Men might easily have found out these or the like Reconciliations of Scriptural expressions; to whom nevertheless I have thought fit (in respect of that profession which I have undertaken, upon the faith of my soul, and the propensity that I have towards Truth) to offer that of the Poet,

Nullius additus jurare in verba Magistri.

And in testimony of my esteem to them and all the Learned, to communicate these my thoughts; confidently assuring my self that they will accept them, with a Candor equal to that wherewith I have written them.

Therefore to come to the business: All Authorities of Divine Writ which seem to oppose this Opinion, are reducible to six Classes: The first is of those that affirm the Earth to stand still, and not to move: as *Psal. 92. He framed the round World so sure, that it cannot be moved: Also Psal. 104. Who laid the Foundations of the Earth, that it should not be removed for ever: And Ecclesiastes 1. But the Earth abideth for ever: And others of the like sense.*

The second is of those which attest the Sun to move, and Revolve

The Author first Theologically defended the Earths Mobility, approved by many of the Moderns.

Revolve about the Earth; as *Psal.* 19. (b) *In them hath he set a Tabernacle for the Sun, which cometh forth as a Bridegroom out of his chamber, and rejoyceth as a Gyant to run his Course. It cometh forth from the uttermost part of the Heaven, and runneth about unto the end of it again; and there is nothing hid from the heat thereof. And Ecclesiast.* 1. *The Sun riseth, and the Sun goeth down, and hasteth to the place where he arose: it goeth towards the South, and turneth about unto the North.* Whereupon the Suns Retrogradation is mentioned as a Miracle, *Isaiah* 38. *The Sun returned ten degrees. And Ecclesiasticus* 48. *In his time the Sun went backward, and lengthened the life of the King.* And for this reason it is related for a Miracle, in the Book of *Josuah*, that at the Prayers of that great Captain the Sun stood still, its motion being forbidden it, by him: *Josb.* 10. *Sun stand thou still upon Gibeon.* Now if the Sun should stand still, and the Earth move about it, its station at that time was no Miracle; and if *Josuah* had intended, that the light of the day should have been prolonged by the Suns splendour, he would not have said, *Sun stand thou still*, but rather *Earth stand thou still*.

(b) Or In Sole posuit tabernaculum suum, according to the Translation our Author followeth.

The third Classis is of those Authorities which say, that Heaven is *above*, and the Earth *beneath*; of which sort is that place of *Joel*, chap. 2. cited by S. Peter, in *Acts.* 2. *I will shew wonders in Heaven above, and signes in the Earth beneath*, with others of the like purport. Hereupon Christ at his Incarnation is said to *come down from Heaven*; and after his Resurrection to have *ascended up into heaven*. But if the Earth should move about the Sun, it would be, as one may say, in Heaven, and consequently would rather be *above* Heaven than *beneath* it. And this is confirmed; For that the Opinion which placeth the Sun in the Centre, doth likewise place *Mercury* above the Sun, and *Venus* above *Mercury*; and the Earth above *Venus*, together with the Moon, which revolves about the Earth, and therefore the Earth, together with the Moon, is placed in the third Heaven. If therefore in Spherical Bodies, as in the World, *beneath* signifies no more than to be neer to the centre, and *above*, than to approach the Circumference, it must needs follow, that for making good of Theological Positions concerning the Ascension and Descension of Christ, the Earth is to be placed in the centre, and the Sun, with the other Heavens in the Circumference; and not according to *Copernicus*, whose Hypothesis inverts this Order: with which one cannot see how the true Ascension and Descension can be consistent.

In Sphericall Bodies, Deorsum is the Centre, and Sursum the Circumference.

The fourth Classis is of those Authorities which make Hell to be in the Centre of the World, which is the Common Opinion of Divines, and confirmed by this Reason, That since Hell (ta-

ken

*Hell is in the
centre of the
Earth, not of the
World.*

*Heaven and
Earth are always
mutually opposed
to each other.*

ken in its strict denomination) ought to be in the lowest part of the World, and since that in a Sphere there is no part lower then the Centre, Hell shall be, as it were, in the Centre of the World, which being of a Spherical Figure, it must follow, that Hell is either in the Sun (forasmuch as it is supposed by this Hypothesis to be in the Centre of the World) or else supposing that Hell is in the Centre of the Earth, if the Earth should move about the Sun, it would necessarily ensue, that Hell, together with the Earth, is in Heaven, and with it revolveth about the third Heaven; than which nothing more absurd can be said or imagined.

The fifth Classis, is of those Authorities which always oppose Heaven to the Earth, and so again the Earth to Heaven; as if there were the same relation betwixt them, with that of the Centre to the Circumference, and of the Circumference to the Centre. But if the Earth were in Heaven, it should be on one side thereof, and would not stand in the Middle, and consequently there would be no such relation betwixt them; which nevertheless do, not only in Sacred Writ, but even in Common Speech, ever and every where answer to each other with a mutual Opposition. Whence that of Genes. 1. *In the beginning God created the Heaven and the Earth*: and Psal. 115. *The Heaven, even the heavens are the Lords; but the Earth hath been given to the Children of men*: and our Saviour in that Prayer which he prescribeth to us, Matth. 6. *Thy will be done in Earth, as it is in Heaven*: and S. Paul, 1 Corinth. 15. *The first man is of the Earth, earthy; the second man is of Heaven, heavenly*: and Coloss. 1. *By him were all things created that are in Heaven, and that are in Earth*: and again, *Having made peace through the Blood of his Crosse for all things, whether they be things in Earth or things in Heaven*: and Chap. 3. *Set your affections on things above, not on things on the Earth*; with innumerable other such like places. Since therefore these two Bodies are always mutually opposed to each other, and Heaven, without all doubt, referreth to the Circumference, it must of necessity follow, that the Earth is to be adjudged the place of the Centre.

*After the day
of Judgment the
Earth shall stand
immoveable.*

The sixth and last Classis is of those Authorities, which (being rather of Fathers and Divines, than of the Sacred Scripture) say, That the Sun, after the day of Judgment shall stand immoveable in the East, and the Moon in the West. Which Station, if the Pythagorick Opinion hold true, ought rather to be ascribed to the Earth, than to the Sun; for if it be true, that the Earth doth now move about the Sun, it is necessary that after the day of Judgment it should stand immoveable. And truth is, if it must subsist without motion in one constant place, there is no reason why

why it should rather stand in one site of that Place than in another, or why it should rather turn one part of it than another to the Sun, if so be that every of its parts without distinction, which is destitute of the Sun's light, cannot choose but be dismal, and much worse affected than that part which is illuminated. Hence also would arise many other absurdities besides these.

These are the Classes, &c. from which great assaults are made against the structure of the Pythagorick System; yet by that time I shall have first laid down six Maxims or Principles, as impregnable Bulwarks erected against them, it will be easie to batter them, and to defend the Hypothesis of *Pythagoras* from being attacked by them. Which, before I propound, I do profess (with that Humility and Modesty which becometh a Christian, and a person in Religious Orders) that I do with reverence submit what I am about to speak to the Judgment of Holy Church. Nor have I undertaken to write these things out of any inducements of Temerity, or Ambition, but out of Charity and a Desire to be auxiliary to my neighbour in his inquisition after Truth. And there is nothing in all this Controversie maintained by me (that expect to be better instructed by those who profess these Studies) which I shall not retract, if any persons shall by solid Reasons & reiterated Experiments, prove some other Hypothesis to be more probable; but yet, until such time as they shall decide the Point, I shall labour all I can for its support.

My first and chiefest Maxime is this; When any thing is attributed in Holy Writ, to God, or to a Creature, that's not be- seeming to, or incommensurate with them, it must of necessity be received and expounded one, or more of the four following wayes; First, it may be said to agree with them *Metaphorically, and Proportionally, or by Similitude*. Secondly, *According to our manner of Considering, Apprehending, Conceiving, Understanding, Knowing, &c.* Thirdly, *according to the Opinion of the Vulgar, and the Common way of Speaking*: to which Vulgar Speech the Holy Ghost doth very often with much study accommodate it self. Fourthly, *In respect of our selves, and for that he makes himself like unto us*. Of each of these wayes there are these examples: God doth not walk, since he is Infinite and Immoveable; He hath no Bodily Members, since he is a Pure Act; and consequently is void of all Passion of Minde; and yet in Sacred Scripture, *Gen. 3. vers. 8.* it is said, *He walked in the cool of the day*: and *Job 22. vers. 14.* it is said, *He walketh in the Circuit of Heaven*: and in many other places coming, departing, making hast is ascribed to God; and likewise Bodily parts, as Eyes, Ears, Lips, Face, Voice, Countenance, Hands, Feet, Bowels, Garments, Arms; as also many Passions, such as Anger,

Ppp

Sor-

* Circa Cardines Caeli.

Sorrow, Repentance, and the like. What shall we say therefore? Without doubt such like Attributes agree with God (to use the Schoolmens words *Metaphorically, Proportionally, and by Similitude*: And touching Passions, it may be said, that God condescendeth to represent himself after that manner: as for instance, *The Lord is angry*; i.e. *He revealeth himself as one that is angry*: *He grieved*; i.e. *He revealeth himself, as one that is sorrowful*: *It repented him that he had made man*; i.e. *He seemed as one that repented*. And indeed all these things are *Comparative ad nos*, and in respect of us. So God is said to be in Heaven, to move in time, to shew himself, to hide himself, to observe and mark our steps; to seek us, to stand at the door, to knock at the door; not that he can be contained in a bodily place; nor that he is really moved, nor in time; nor that humane manners or customes can agree with him, save only according to our manner of Apprehension: This Conception of ours orderly distinguisheth these Attributes in him one from another, when, notwithstanding, they are one and the same with him: This Apprehension of ours divideth also his actions into several times, which, neverthelesse, for the most part, are produced in one and the same instant: And this, to conclude, alwayes apprehendeth those things with some defect, which, notwithstanding are in God most perfect. For this reason doth the Sacred Scripture express it self according to the *Vulgar Opinion*, whilst it ascribes to the Earth Ends and Foundations, which yet it hath not; to the Sea a Depth not to be fathomed; to Death (which is a Privation, and consequently a Non-entity) it appropriates Actions, Motion, Passions, and other such like Accidents, of all which it is deprived, as also Epithites and Adjuncts, which really cannot suit with it: *Is not the bitterness of Death past?* 1 Sam. 15. 32. *Let death come upon them*, Psal. 6. *He hath prepared the Instruments of Death*, Psal. 7. 14. *Thou raisest me from the gates of Death*, Psal. 84. *In the midst of the shadow of Death*, Psal. 23. *Love is strong as Death*, Cant. 8. 9. *The First-Born of Death*, Job 18. 13. *Destruction and Death say, &c.* Job 28. 22. And who knows not that the whole History of the rich Glutton doth consist of the like phrases of *Vulgar Speech*? So *Ecclesiasticks*, Chap. 27. vers. 11. *The godly man abideth in wisdom, as the Sun*; but a *fool changeth as the Moon*; and yet the Moon according to the real truth of the matter no wayes changeth, but abides the same for ever, as *Astronomers* demonstrate; one half thereof remaining alwayes lucid, and the other alwayes opacous. Nor at any time doth this state vary in it, unlesse in respect of us, and according to the opinion of the *Vulgar*. Hence it is cleer, that the holy Scripture speaks according to the common form of speech used

Luke 16.

fed amongst the unlearned, and according to the appearance of things, and not according to their true Existence. In like manner Genes. 1. in the description of the Creation of all things, the Light is said to be made first of all, and yet it followeth in the Text, *And the Evening and the Morning made the first day*: and a little after the several Acts of the Creation are distinguished and assigned to several days, and concerning each of them it is said in the Text, *And the Evening and the Morning made the second day*; and then *the third day, the fourth day, &c.* Hence many doubts arise, all which I shall propound according to the common Systeme, that it may appear even from the Hypothesis of that Systeme, that the sacred Scripture sometimes, for the avoyding of emergent difficulties, is to be understood in a vulgar sense and meaning, and in respect of us, and not according to the nature of things. Which distinction even Aristotle himself seemeth to have hinted, when he saith, * *Some things are more intelligible to us; others by nature, or secundum se.*

First therefore; If the light were made before heaven, then it rolled about without heaven to the making of the distinction of Day and Night. Now this is contrary to the very doctrine of these men, who affirm that no Cœlestial Body can be moved unless *per accidens*, and by the motion of Heaven, and as a knot in a board at the motion of the board. Again, if it be said, that the Light was created at the same time with Heaven, and began to be moved with Heaven, another doubt ariseth, that likewise opposeth the foresaid common Hypothesis: For it being said, that Day and Night, Morning and Evening were made, that same is either in respect of the Universe, or onely in respect of the Earth and us. If so be that the Sun turning round (according to the Hypothesis of the Common Systeme) doth not cause the Night and Day, but only to opacous Bodies which are destitute of all other light, but that of the Sun, whilst in their half part (which is their Hemisphere) and no more, (for that the Sun's light passeth over but one half of an opacous Body, unless a very small matter more in those of lesser bulk) they are illuminated by the Sun's aspect, the other half remaining dark and tenebrous, by reason of a shadow proceeding from its own Body. Therefore the distinction of dayes by the light of heaven, according to the description of them in the sacred Scriptures, must not be understood absolutely, and secundum se, and Nature herself; but in respect of the Earth, and of us its inhabitants, and consequently secundum nos. 'Tis not therefore new, nor unusual in sacred Scripture to speak of things secundum nos, and onely in respect of us, and secundum apparentiam; but not secundum se, and rei naturam, or Absolutely and Simply.

Alia sunt notiora nobis, alia, notiora natura, vel secundum se, Arist. lib. 1. Phys.

PPP 2

And

* Aut ad Umbram

And if any one would understand these Days of sacred Scripture, not only *secundum nos*, but also *secundum naturam*, as circulations of Cœlestial Light returning to the self same point from whence it did at first proceed; so as that there needs no respect to be had to Night or to * Darknesse, for which sole reason we are fain to imbrace the Interpretation of sacred Scripture *secundum nos*; In opposition to this we may thus argue: If the sacred Scripture be understood to speak *absolutely*, of iterated and successive circulations of light, and not *respectu nostri*, as if these words *Evening and Morning* had never been inserted, which in their natural acceptation denote the Suns habitude to us and to the Earth: For that the *Morning* is that time when the Sun begins to wax light, and to rise above the *Horizon* in the East, and become visible in our *Hemisphere*, and *Evening* is the time in which the Sun declines in the West, and approacheth with its light neerer to the other opposite *Horizon* and *Hemisphere*, which is contiguous to this of ours. But the word *Day* is a *Co-relative* to the word *Night*. From hence therefore it evidently appeareth, that these three words *Evening, Morning, and Day*, cannot be understood of a Circulation of Light *secundum se*, and *absolutè*, but only *secundum nos*, and *respectu nostri*; and in that sense indeed the *Morning* and *Evening* do make the *Night* and *Day*,

Which are really
the great Lights
in Heaven.

In like manner, *Gen. i. 16.* it is said, *God made two great Lights; the greater Light to rule the Day, and the lesser Light to rule the Night, and the Stars.* Where both in the Proposition and in the specification of it, things are spoken which are very disagreeing with Cœlestial Bodies. Therefore those words are in that place to be interpreted according to the foresaid Rules; namely, according to the third and fourth; so that they may be said to be understood according to the sense of the vulgar, and the common way of speaking, which is all one, as if we should say, *secundum apparentiam*, and *secundum nos, vel respectu nostri*. For first, it is said in the Proposition, *And God made two great Lights;* meaning by them the Sun and Moon, whereas according to the truth of the matter these are not the Greater Lights; For although the Sun may be reckoned amongst the Greater, the Moon may not be so, unless in respect of us. Because amongst those that are absolutely the Greater, and a little lesser than the Sun (nay in a manner equal to it) and far bigger than the Moon, we may with great reason enumerate *Saturn*, or some of the Fixed Stars of the first Magnitude, such as *Canopus*, (otherwise called *Arcanar*) in the end of a River; or the *Little Dog* in the mouth of the *Great Dog*; or the Foot of *Orion*, called *Rigel*; or his *Right shoulder*, or any other of that Magnitude. There-

Therefore the *two great Lights* are to be understood in respect of us, and according to vulgar estimation, and not according to the true and reall existence of such Bodies. Secondly, in the specification of the Proposition it is said, *The greater Light to rule the Day*; hereby denoting the Sun; in which the verbal sense of Scripture agreeth with the Truth of the Thing; For that the Sun is the Greatest of all Luminaries, and Globes. But that which followeth immediately after, *And the lesser Light to rule the Night*, meaning the Moon, cannot be taken in the true and real sense of the words: For the Moon is not the lesser Light, but *Mercury*; which is not only much lesser than the Moon, but also than any other Star. And if, again, it be said, That the Holy Text doth not speak of the Stars, but onely of the Luminaries; for that presently after they are mentioned apart, *And the Stars*; and that what we say is true touching the comparison of the Stars amongst themselves, but not in respect of the Luminaries, namely, the Sun and Moon: This reply doth discover a man to be utterly ignorant in these Studies, and such who having not the least smattering in them, doth conceive an absurd and erroneous Opinion of the Cœlestial Bodies. For the Moon and Sun, considered in themselves, and as they appear to us, if they should be a far greater distance from us, than indeed they are, would be no other, nor would appear to us otherwise than Stars; as the rest do in the Firmament. But Great Luminaries they neither are, nor seem to be, save only *in respect of us*: And so, on the other side, the Stars, as to themselves, are no other than so many Suns and so many Moons; yet are so far remote from us, that by reason of their distance they appear thus small, and dim of light, as we behold them. For the greater and lesser distance of heavenly Bodies (*ceteris paribus*) doth augment and diminish their appearance both as to Magnitude and Light. And therefore the words which follow in that place of *Genesis*, *And the Stars* (as distinguishing the Stars from the Sun and Moon) are to be taken in no other acceptation than that which we have spoken of, namely, *according to the sense of the Vulgar, and the common manner of speech*. For indeed, according to the truth of the matter, all Cœlestial Bodies, being shining Globes, are of a vast bigness, to which if we should be so neer as we are to the Moon, they would seem to us of as great, yea a greater magnitude than the Moon: As likewise on the contrary, if we were as far distant from the Sun and Moon, as we are from them, both Moon and Sun would shew but as stars to us. And yet the splendor of the Sun would doubtless be greater *intensive* than that of any other star. For, although it should be granted that some stars (as those of the Fixed that twinkle) do shine of themselves

*The Sun, Moon,
and Stars are one
& the same thing.*

selves, and by their own nature, as the Sun, that derives not its light from others (which yet remains undecided and doubtful) and borrow not their light from the Sun; Nevertheless since the brightness of none of the stars may be compared with the Sun's splendour, which was created by God first, and before all other Luminaries, in the highest kind of Light, it would therefore notwithstanding follow, that none of those stars, although placed in the same proximity to us with the Sun, and therefore appearing to us of the same Magnitude as the Sun, can bestow upon us so much Light as we receive from the Sun: As on the contrary, the Sun, at the same remoteness from us as they are, would indeed, as to its Magnitude, appear to us as one of those stars, but of a splendour much more *intense* than that of theirs. So that, now, the Earth is nothing else but another Moon or star, and so would it appear to us, if we should behold it from a convenient distance *on high*. And in it might be observed (in that variety of Light and Darknes which the Sun produceth in it by making Day and Night) the same difference of Aspects that are seen in the Moon, and such as are observed in tricorporate *Venus*; in like manner also 'tis very probable that the same might be discerned in other Planets, which shine by no light of their own, but by one borrowed from the Sun. What ever therefore may touching these matters be delivered in the sacred Leaves or the common speech of men, dissenting from the real truth, it ought (as we have said before) absolutely to be received and understood *secundum vulgi sententiam, & communem loquendi & concipiendi stylum*.

The Earth is another Moon or Star.

Why the Sunne seemeth to us to move, & not the Earth.

And so, to return to our purpose, if, all this considered, the *Pythagorian* opinion be true, it will be easie, according to the same Rule, to reconcile the authority of sacred Scriptures with it, however they seem to oppose it, and in particular those of the first and second Classis, *scilicet* by my first *Maxime*: For that in those places the holy Records speak according to our manner of understanding, and according to that which appeareth in respect of us; For thus it is with those Bodies, in comparison of us, and as they are described by the vulgar and commune way of humane Discourse; So that the Earth appears as if it were standing still and immoveable, and the Sun, as if it were circumambient about her. And so the Holy Scripture is used in the Commune and Vulgar way of speaking; because in respect of our sight, the Earth seems rather to stand fixed in the Centre, and the Sun to circumsolve about it, than otherwise: as it happens to those that are putting off from the Banks of a River to whom the shore seems to move backwards, and go from them: but they do not perceive (which yet is the truth) that they themselves go forwards. Which

Which fallacy of our sight is noted, and the Reason thereof assigned by the Opticks; upon which, as being strange to, and besides my purpose, I will not stay) and on this account is *Aeneas* brought in by *Virgil*, saying;

Provehimur portu, terraque urbesque recedunt.

Aeneid. 3.

But it will not be amiss to consider why the sacred Scripture doth so studiously comply with the opinions of the Vulgar, and why it doth not rather accurately instruct men in the truth of the matters, and the secrets of Nature. The Reason is, first, the benignity of Divine Wisdom, whereby it sweetly accomodates it self to all things, in proportion to their Capacity and Nature. Whence in Natural Sciences, it useth natural and necessary causes, but in Liberal Arts it worketh liberally, upon Generous Persons after a sublime and lofty manner; upon the Common People, familiarly and humbly; upon the Skilful, learnedly; upon the Simple, vulgarly; and so on every one, according to his condition and quality. Secondly, because it is not its Intention to fill our mindes in this life with vain and various curiosities, which might occasion our doubt and suspense. For the truth is, (a) *He that increaseth knowledge, increaseth sorrow.* Moreover it did not only permit, but even decree, that the World should be very much busied in Controversies and Disputations, and that it should be employed about the uncertainty of things; according to that saying of *Ecclesiastes* (b) *He hath set the World in their heart; so that no man can find out the work that God maketh from the beginning unto the end.* And touching those doubts, God will not permit that they shall be discovered to us before the end of the World: (c) *At which time he will bring to light the hidden things of darkness:* But Gods onely scope in the sacred Scripture is to teach men those things which conduce to the attainment of Eternal Life; which having obtained, (d) *We shall see him face to face:* (e) *and shall be like him, for we shall see him as he is.* Then shall he clearly à *Priori* make known unto us all those Curiosities, and Dogmatical Questions, which in this life, (f) *in which we see through a Glasse darkly,* could be known by us but imperfectly and à *posteriori*, and that not without much pains and study. For this cause the Wisdom of God, revealed to us in the sacred Leaves, is not stiled Wisdom absolutely, but (g) *Saving Wisdom;* Its onely end being to lead us to salvation. And *S. Paul* preaching to the *Corinthians*, saith; (h) *I determined to know nothing among you, save Jesus Christ, and him crucified:* whereas notwithstanding he was thorowly instructed, and profoundly learned

(a) *Eccles. i. 1. v. ult.*

(b) *Chap. 3. v. 11.*

(c) *1 Cor. i. 4. v. 5*

(d) *1 Cor. c. 13. v. 12.*

(e) *1 John c. 3. v. 2.*

(f) *1 Cor. c. 13. v. 12.*

(g) *Ecclesiast. 15. 3*

(h) *1 Cor. c. 2. v. 2*

in

(i) Isa. c. 48. v. 17.

in all humane Sciences; but making no account of these things he professeth that it was his desire to teach them no more but the way to Heaven. Hence is that which God speaketh to us by *Isaiab*, (i) *Ego Dominus Deus, docens te utilia* [I am the Lord thy God which teacheth thee profitable things:] Where the *Glossary* addeth, *non subtilia* [not subtilties.] For God neither taught us, Whether the *Materia Prima* of Heaven, and the Elements be the same; nor Whether *Continual* be composed of Indivisibles, or whether it be divisible *in infinitum*; nor, whether the Elements are formally *mixt*; nor how many the *Cœlestial Spheres*, and their Orbs are; Whether there be *Epicycles* or *Eccentrics*; nor the Vertues of Plants and Stones; nor the Nature of Animals; nor the Motion and Influence of the Planets; nor the Order of the Universe; nor the Wonders of Minerals, and universal Nature: but only [*utilia*:] things profitable, to wit, his Holy Law ordained to the end, that we being put into possession of Blessedness, might at length be made capable of all perfect knowledge, and the vision of the whole Order and admirable Harmony, as also the Sympathy and Antipathy of the Universe and its parts, *in his Word*; wherein all those things shall most clearly and distinctly, then, appear to us, which mean while, in this life, he hath remitted (as far as its ability reacheth) to humane search and enquiry: But it was not his purpose to determine any thing, directly or indirectly, touching the truth of them. Because as the knowledge thereof would little or nothing profit Us, but might in some cases prove prejudicial; so the ignorance thereof can doubtless be no detriment, but may in some cases be very beneficial to us. And therefore by his most admirable Wisdom it comes to pass, that though all things in this World are dubious, uncertain, wavering, and perplexed; yet his Holy Faith alone is most certain; and although the opinions about Philosophical and Doctrinal points be divers, there is in the Church but one Truth of Faith and Salvation. Which Faith, as necessary to Salvation, is so ordered by Divine Providence, that it might not only be indubitable, but also unshaken, sure, immutable, and manifest to all men: the infallible Rule of which he hath appointed the Holy Church, that is washed with his precious Blood, and governed by his Holy Spirit, to whom belongs our Sanctification, as being his work. This therefore is the Reason why God would have Speculative Questions, which nothing conduce to our Salvation and Edification, and why the Holy Ghost hath very often condescended to Vulgar Opinions and Capacities, and hath discovered nothing that is singular or hidden to us, besides those things that pertain to Salvation. So that consequently it is clear by what hath been said, how and why

2 Thess. 4.

why nothing of certainty can be evinced from the foresaid Authorities to the determining of Controversies of this Nature; as also with what Reason from this first *Axiome* the Objections of the first and second Classe are easily answered, as also any other Authority of sacred Scripture produced against the *Pythagorean* and *Copernican* Systeme so long as by other proofs it is true.

And the Authorities of the second Classe in particular by this same Maxime, *Of the ordinary manner of apprehending things as they appear to us, and after the common way of speaking*, may be thus reconciled and expounded; namely, Oftentimes an Agent is commonly, and not improperly said to move, (though it have no motion) not because it doth indeed move, but by *extrinsecal denomination*, because receiving its influence and action at the motion of the Subject; the Form and Quality infused to the Subject by the said Agent doth likewise move. As for example, a Fire burning in a Chimney is an immoveable Agent, before which a man oppressed with cold sits to warm himself who being warmed on one side, turns the other to the Fire, that he may be warmed on that side also, and so in like manner he holds every part to the Fire successively, till his whole body be warmed. 'Tis clear, that although the Fire do not move, yet at the Motion of the Subject, to wit the Man, who receiveth the heat, and action of the Fire, the Form and Quality of its Heat doth move *singulariter*, & *per partes*, round about the mans body, and alwayes seeketh out a new place: and so, though the Fire do not move, yet by reason of its effect, it is said to go round all the parts of the Mans body, and to warm it, not indeed by a true and real motion of the Fire it self, since it is supposed (and that not untruly) not to move, but by the motion to which the Body is excited, out of a desire of receiving the heat of the Fire in each of its parts. The same may be applied to the Illumination impressed successively on the parts of any Globe, which moves Orbicularly at the aspect of a shining immoveable Light. And in the same manner may the Sun be said to rise and set, and to move above the Earth, although in reality he doth not move, nor suffer any mutation; that is to say, Inasmuch as his Light (which effect is the Form and Quality proceeding from him, as the Agent, to the Earth as the Subject) doth sensibly glide forwards, by reason of the Orbicular motion of the Earth; and doth alwayes betake it self to some new place of her surface; upon which ground he is truly said (*secundum vulgarem sermonem*) to move above, and revolve about the Earth: Not that the Sun doth move, (for by this Opinion we affirm the Earth to move, that it may receive the Sun one while in one, another while in another part of it) but that at the motion of the Earth

Qq q

het

her self a contrary way, the Quality diffused into her, and impressed upon her by the Sun, namely the Light of the Day is moved, which riseth in one part of her, and sets in another contrary to that, according to the nature and condition of her motion; And for this reason the Sun it self by consequence is said to rise and set, (which notwithstanding *ex Hypothesi* stands immoveable) and that no otherwise then *per denominationem extrinsecam*, as hath been said.

Joshua c. 10.
ver. 12.

expelled.

Isa. c. 38. v. 8.

After this manner the command of *Josuah*, *Sun stand thou still*, and the Miracle of the Suns cessation of Motion wrought by him, may be so understood, as that not the Solar Body properly, but the Suns splendour upon the Earth stood still; so that not the Sun it self, (being of it self before that time immoveable) but the Earth that receiveth its splendour, stayed her Motion; which, as she incessantly pursuing her ordinary Motion towards the East, * called up the Light of the Sun in the West, so standing still, the Suns light imprest upon it likewise stood still. After the same maner proportionally is that Text of *Isaiah* explained, touching the Suns going ten degrees backward upon the Dial of *Ahaz*. So (which may serve for another Example) the Hand being moved about the flame of a burning Candle that stands still, the Light moveth on the Hand, that is to say, the said Hand is illustrated now in one part, anon in another, when as the Candle it self all the while removes not out of its place: whereupon *per denominationem extrinsecam*, the said Light may be affirmed to rise and set upon the Hand, namely, by the sole motion of the said Hand, the Candle it self never moving all the while. And let this suffice for the explanation of my first Principle or *Maxime*, which by reason of its difficulty and extraordinary weight required some prolixity in the handling of it.

My second *Maxime* is this: Things both Spiritual and Corporeal, Durable and Corruptible, Moveable and Immoveable, have received from God a perpetual, unchangeable, and inviolable Law, constituting the Essence and Nature of every one of them: according to which Law all of them in their own Nature persisting in a certain Order and Constancy, and observing the same perpetual Course, may deservedly be stiled most Stable and Determinate. Thus Fortune (than which there is nothing in the World more inconstant or fickle) is said to be constant and unalterable in her continual volubility, vicissitude, and inconstancy, which was the occasion of that Verse,

Et semper constans in levitate sua est.

And thus the motion of Heaven (which by the constant Law of

of Nature ought to be perpetual) may be said to be immutable and immoveable, and the Heavens themselves to be immoveably moved, and Terrene things to be immutably changed, because those never cease moving, nor these changing. By this Principle or Maxime all difficulties belonging to the first Classis are cleared, by which the Earth is said to be stable and immoveable, that is, by understanding this one thing, That the Earth, as to its own Nature, though it include in it self a local Motion, and that threefold, according to the opinion of Copernicus (*scilicet* Diurnal, with which it revolveth about its own Centre; Annual; by which it moveth through the twelve Signes of the Zodiack, and the motion of Inclination, by which its Axis is alwayes opposed to the same part of the World) as also other Species of Mutation, such as Generation and Corruption, Accretion and Diminution, and Alteration of divers kinds; yet in all these she is stable & constant, never deviating from that Order which God hath appointed her, but moveth continually, constantly and immutably, according to the six before named Species of Motion.

My third Maxime shall be this; When a thing is moved according to some part of it, and not according to its whole, it cannot be said to be *simply & absolutely* moved, but only *per accidens*, for that stability taken simply & absolutely do rather accord with the same. As for example, if a Barrel or other measure of Water be taken out of the Sea, and transferred to another place, the Sea may not therefore *absolutely & simply* be said to be removed from place to place, but only *per accidens*, and *secundum quid*, that is, according to a part of it, but rather (to speak simply) we should say that the Sea cannot be carried or moved out of its proper place, though as to its parts it be moved, and transferred to & again. This Maxime is manifest of it self, and by it may the Authorities be explained which seem to make for the immobility of the Earth in this manner; namely, The Earth *per se & absolute* considered as to its *Whole*, is not mutable, seeing it is neither generated nor corrupted neither increased nor diminished; neither is it altered *secundum totum*, but only *secundum partes*. Now it plainly appears; that this is the genuine and true Sense of what is ascribed to it out of Ecclesiastes, cap. i. v. 4. *One Generation passeth away, and another Generation cometh, but the Earth abideth for ever*: as if he should say; although the Earth, according to its parts, doth generate and corrupt, and is liable to the vicissitudes of Generation and corruption, yet in reference to its Whole it never generateth nor Corrupteth, but abideth immutable for ever: Like as a Ship, which though it be mended one while in the Sail-yard, another while in the Stern, and afterwards in other parts it yet remains the same Ship as it was at first. But tis to be ad-

Q q q 2

verified

Several Motions
of the Earth ac-
cording to Coper-
nicus.

The Earth Se-
cundum Totum is
Immutable,
though not Immo-
vable.

vertized, that that Scripture doth not speak of a Local Motion, but of Mutations of another nature; as in the very substance, quantity or quality of the Earth it self. But if it be said, that it is to be understood of a Local Motion, then it may be explained by the insuing Maxime, that is to say, a respect being had to the natural Place assigned it in the Universe, as shall be shewed by and by.

The Earth cannot Secundum Totum, remove out of its Natural Place.

The Natural Place of the Earth.

The Moon is an Ætherial Body.

The fourth Axiome is this; That every Corporeal thing, moveable or immoveable from its very first Creation, is allotted its proper and natural place; and being drawn or removed from thence, its motion is violent, and it hath a natural tendency to move back thither again: also that nothing can be moved from its natural place, *secundum Totum*; For most great and dreadful mischiefs would follow from that perturbation of things in the Universe. Therefore neither the whole Earth, nor the whole Water, nor the whole Air can *secundum totum* be driven or forced out of their proper place, site, or Systeme in the Universe, in respect of the order and disposition of other mundane Bodies. And thus there is no Star (though Erratick) Orb or Sphere that can desert its natural place, although it may otherwise have some kind of motion. Therefore all things, how moveable soever, are notwithstanding said to be stable and immoveable in their proper place, according to the foresaid sense, *i.e. secundum totum*; For nothing hinders, but that *secundum partes* they may some way move; which motion shall not be natural, but violent. Therefore the Earth, although it should be moveable, yet it might be said to be immoveable, according to the precedent Maxime, for that its neither moved in a right Motion nor out of the Course assigned it in its Creation for the standing Rule of its motion; but keep within its own site, being placed in that which is called the Grand Orb, above *Venus*, and beneath *Mars*, and being in the middle betwixt these (which according to the common opinion is the Sun's place) it equally and continually moveth about the Sun; and the two other intermediate Planets, namely *Venus* and *Mercury*, and hath the Moon (which is another Earth, but Ætherial, as *Macrobius* after some of the ancient Philosophers, will have it) about it self. From whence, inasmuch as she persisteth uniformly in her Course, and never at any time departeth from it, she may be said to be stable and immoveable: and in the same sense Heaven likewise, with all the Elements, may be said to be immoveable.

The fifth Maxime followeth, being little different from the former. Amongst the things created by God, some are of such a nature, that their parts may be *ab invicem*, or by turns, separated from themselves, and dis-joyned from their Whole; others

others may not, at least, taken *collectively*: now those are perishable, but these perpetual. The Earth therefore since it is reckoned amongst those things that are permanent, as hath been said already, hath its parts, not dissolvable, nor *ab invicem*, separable from its Centre (whereby its true and proper place is assigned it) and from its whole, taken *collectively*: because according to its whole it is always preserved, compact, united, and coherent in it self, nor can its parts be separated from the Centre, or from one another, unless it may so fall out *per accidens*, and violently in some of its parts; which afterwards, the obstacle being removed, return to their Natural Station spontaneously, and without any impulse. In this Sense therefore the Earth is said to be Immoveable, and Immutable: yea even the Sea, Aire, Heaven, and any other thing (although otherwise moveable) so long as its parts are not dissolvable and separable, may be said to be Immoveable, at least taken *collectively*. This Principle or Maxim differeth from the precedent only in that this refers to the parts in order to *Place*, and this, in order to the Whole.

The Earths Centre keepeth it in its Natural Place.

From this Speculation another Secret is discovered. For hence it is manifest wherein the proper and genuine formality of the Gravity and Levity of Bodies consisteth; a point which is not so clearly held forth, nor so undeniably explained by the Peripatetic Philosophy. Gravity therefore is nothing else according to the Principles of this new Opinion, than a certain power and appetite of the Parts to rejoyne with their Whole, and there to rest as in their proper place. Which Faculty or Disposition is by Divine Providence bestowed not only on the Earth, and Terrene Bodies, but, as is believed, on Cœlestial Bodies also, namely the Sun, Moon, and Stars; all whose parts are by this Impulsion connected, and conserved together, cleaving closely to each other, and on all sides pressing towards their Centre, until they come to rest there. From which Concourse and Compression a Spherical and Orbicular Figure of the Cœlestial Orbes is produced, wherein by this occult Quality naturally incident to each of them they of themselves subsist, and are alwayes preserved. But Levity is the Extrusion and Exclusion of a more tenuous and thin Body from the Commerce of one more Solid and dense, that is Heterogeneous to it, by vertue of Heat. Whereupon, as the Motion of Grave Bodies is *Compressive*, so the Motion of Light Bodies is *Extensive*: For its the property of Heat to dilate and rarify those things to which it doth apply, conjoine and communicate it self. And for this reason we find Levity and Gravity not only in respect of this our Terrestrial Globe, and the Bodies adjacent to it, but also in respect of those Bodies which are said to be in the Heavens, in which those parts which by

Gravity and Levity of Bodies, what is it.

All Cœlestial Bodies have Gravity and Levity.

Compressive Motion, proper to Gravity; the Extensive, to Levity.

Heaven is not
composed of a fifth
Essence differing
from the matter of
inferior Bodies.

Nor yet a Solid
or dense Body but
Rare.

* Delle Macchie
solarj.

* Unius Corporis
simplicitas, unus est
motus simplex, et
huius duo species,
Rectus & Circularis: Rectus duplex
ad medium, &
ad medium; primus
levium, ut Aeris & Ignis: secundus
graviorum, ut Aqua & Terra: Circularis,
qui est circa medium
competit Caelo,
quod neque est
grave, neque leve.
Arist. de Caelo.
Lib. 1.

* Vide Coperni-
cum de Revolutionibus
Caelest.

Simple Motion
peculiar to only
Simple Bodies.

by reason of their proclivity make towards their Centre are Grave, and those that incline to the Circumference Light. And so in the Sun, Moon, and Starrs, there are parts as well Grave as Light. And consequently Heaven it self that so Noble Body, and of a fifth Essence, shall not be constituted of a Matter different from that of the Elements, being free from all Mutation in its Substance, Quantity, and Quality: Nor so admirable and excellent as Aristotle would make us to believe; nor yet a solid Body, and impermeable; and much lesse (as the generality of men verily believe) of an impenetrable and most obdurate Density: but in it (as this Opinion will have it) Comets may be generated; and the Sun it self, as tis probable, exhaling or attracting sundry vapours to the surface of its Body, may perhaps produce those Spots which were observed to be so various, and irregular in its *Discus*: of which *Galilaeus* in a perticular * Treatise hath most excellently and most accurately spoken; insomuch, that though it were not besides my present purpose, yet it is convenient that I forbear to speak any thing touching those matters, least I should seem to do that which he hath done before me: But now if there be found in the Sacred Scriptures any Authority contrary to these things, it may be salved by the foresaid Arguments Analogically applied. And furthermore it may be said, that that Solidity is to be so understood, as that it admits of no vacuum, cleft, or penetration from whence the least vacuity might proceed: For the truth is, as that cannot be admitted in bodily Creatures, so it is likewise repugnant to Heaven it self, being indeed a Body of its own Nature the most Rare of all others, and tenuous beyond all Humane Conception, and happily hath the same proportion to the Aire, as the Aire to the Water.

It is clear also from these Principles how false these words of Aristotle are, that: Of one simple Body, there is one simple Motion; and this is of two kinds, Right and Circular: the Right is twofold, from the medium, and to the medium; the first of Light Bodies, as the Aire and Fire: the second of Grave Bodies, as the Water and Earth: the Circular, which is about the medium, belongeth to Heaven, which is neither Grave nor Light: For all this Philosophy is now forsaken, and of it self grown into dis-esteem; for though it be received for an unquestionable truth in this new Opinion, that to a simple body appertains one only simple Motion, yet it granteth no Motion but what is Circular, by which alone a simple body is conserved in its naturall Place, and subsists in its Unity, and is properly said to move *in loco* [in a place:] whereby it comes to pass that a Body for this reason doth continue to move in it self, [or about its own axis;] and although it have a Motion, yet

yet it abideth still in the same place, as if it were perpetually immoveable. But right Motion, which is properly *ad locum*, [to a place] can be ascribed only to those things which are out of their naturall place, being far from union with one another, and from unity with their whole, yea that are seperated and divided from it: Which being that it is contrary to the Nature and forme of the Universe, it necessarily followeth, that right Motion doth in short sute with those things which are destitute of that perfection, that according to their proper Nature belongeth to them, and which by this same right Motion they labour to obtaine, untill they are redintegrated with their Whole, and with one another, and restored to their Naturall place; in which at the length, having obtained their perfection, they settle and remaine immoveable. Therefore in right Motions there can be no Uniformity, nor simplicity; for that they vary by reason of the uncertaine Levity or Gravity of their respective Bodies: for which cause they do not persevere in the same Velocity or Tardity to the end which they had in the beginning. Hence we see that those things whose weight maketh them tend downwards, do descend at first with a slow Motion; but afterwards, as they approach neerer and neerer to the Centre, they precipitate more and more swiftly. And on the otherside, those things which by reason of their lightness are carryed upwards (as this our Terrestriall fire, which is nothing else but a smoak that burneth, and is inkindled into a flame) are no sooner ascended on high, but, in almost the self-same moment, they fly and vanish out of sight; by reason of the rarefaction and extension, that they as soon as they acquire, are freed from those bonds which violently and against their own Nature kept them under, and detained them here below. For which reason, it is very apparent, that no Right Motion can be called Simple, not only in regard that (as hath been said) it is not even and uniforme, but also because it is mixt with the Circular, which lurketh in the Right by an occult consent, *scilicet* by reason of the Natural affection of the Parts to conforme unto their Whole. For when the Whole moveth Circularly, it is requisite likewise that the Parts, to the end that they may be united to their Whole, (howbeit *per accidens* they are sometimes moved with a Right Motion) do move (though not so apparently) with a Circular Motion, as doth their Whole. And thus at length we have evinced that Circular Motion only is Simple, Uniform and *Æquale*, and of the same tenor [or rate] for that it is never destitute of its interne Cause: whereas on the contrary, Right Motion, (which pertains to things both Heavy and Light) hath a Cause that is imperfect and deficient, yea that ariseth from Defect it self, and that tendereth to, and seeketh after no

Right Motion belongeth to Imperfect Bodies, and that are out of their natural Places.

Right Motion cannot be Simple.

Right Motion is ever mixt with the Circular.

** æquabilis;*

** Even; Circular Motion is truly Simple and Perpetual.*

Circular Motion belongs to the whole Body, and the Right to its parts.

Circular and Right Motion co-incident, and may consist together in the same Body.

nothing else but the end and termination of it self: in regard that Grave and Light Bodies, when once they have attained their proper and Natural Place, do desist from that Motion to which they were incited by Levity and Gravity. Therefore: since Circular Motion is proper to the Whole, and Right Motion to the Parts, these differences are not rightly referred to Motion, so as to call one Motion Right, another Circular, as if they were not consistent with one another: For they may be both together, and that Naturally, in the same Body; no less than it is equally Natural for a Man to participate of Sense and Reason, seeing that these differences are not directly opposite to one another. Hereupon Rest and Immobility only are opposed to Motion; and not one Species of Motion to another. And for the other differences *à medio*, *ad medium*, and *circa medium*, they are distinguished not really, but only formally, as the Point, Line and Superficies, none of which can be without the other two, or without a Body. Hence it appears, that in as much as this Philosophy differs from that of Aristotle, so in like manner doth this New Cosmographical System vary from the Common one, that hath been hitherto received. But this by the way, upon occasion of explaining the Fifth Maxim: For as to the truth or falshood of these foregoing Positions (although I conceive them very probable) I am resolved to determine nothing at present, neither shall I make any farther enquiry into them.

The Sixth and Last Maxim is this. Every thing is Simply denominated such as it is in comparison of all things, or of many things which make the greater number of that kinde, but not in respect of a few which make but the lesser part of them. As, for instance, a Vessel shall not be called absolutely Great because it is so whilst it is compared with two or three others: but it shall be said to be great absolutely, and will be so, if it exceed in magnitude all indivials, or the greater part of them. Nor again shall a Man be said to be absolutely Big, because he is bigger than a Pigmey; nor yet absolutely Little, because lesse than a Gyant: but he shall be termed absolutely Big or Little in comparison of the ordinary Stature of the greater part of Men. Thus the Earth cannot absolutely be said to be High or Low for that it is found to be so in respect of some small part of the Universe; nor again shall it be absolutely affirmed to be High, being compared to the Centre of the World, or some few parts of the Universe, more near to the said Centre, as is the Sun, Mercury or Venus: but it shall receive its absolute denomination according as it shall be found to be in comparison of the greater number of the Spheres and Bodies of the Universe. The Earth therefore, in comparison of the whole Circuit of the Eighth Sphere which includeth

The Earth in what sense it may absolutely be said to be in the lowest part of the World,

cludeth all Corporeal Creatures, and in comparifon of *Jupiter*, *Mars*, and *Saturn* together with the *Moon*, and much more in comparifon of other Bodies, (if any fuch there be) above the Eighth Sphere and efpecially the Empyrial Heaven, may be truly faid to be in the loweft place of the World, and almoft in the Centre of it; nor can it be faid to be above any of them, except the *Sun*, *Mercury* and *Venus*: So that one may apply unto it the name of an Infime and Low, but not a Supreme or Middle Body. And fo to come down from Heaven, efpecially the Empyrian, to it (as it is accepted in the Defcent of Chrift from Heaven to his Holy Incarnation) and from it to go up to Heaven (as in Chriffs return to Heaven in his Glorious Afcention) is truly and properly to Defcend from the Circumference to the Centre, and to afcend from the parts which are neareft to the Centre of the World to its utmoft Circumference. This Maxim therefore may eafily and according to truth explain Theologicall Propofitions: and this is fo much the more confirmed, in that (as I have obferved) almoft all Texts of Sacred Scripture which oppofe the Earth to Heaven, are moft conveniently and aptly underftood of the Empyrial Heaven (being the Higheft of all the Heavens, and Spiritual in refpect of its end) but not of the inferiour or intermediate Heavens, which are a Corporeal, and were framed for the benefit of Corporeal Creatures: and thus when in the Plural Number Heavens are mentioned, then all the Heavens promifcuoufly and without diftinction are to be underftood, as well the Empyrian itfelf as the Inferiour Heavens. And this Expoftion indeed any man (that doth but take notice of it) may find to be moft true. And fo for this Reason the Third Heavenu into which *St. Paul* was wrapt up, by this Maxim may be taken for the Empyrean: if for the the Firft Heaven we underftand that immense Space of Erratick and Moveable Bodies illuminated by the Sun, in which are comprehended the Planets, as alfo the Earth moveable, and the Sun immoveable, Who like a King upon his Auguft Tribunal, fits with venerable Majefty immoveable and conftant in Centre of all the Sphares, and, with his Divine Beames, doth bountifully exhilarate all Cœleftial Bodies that ftand in need of his vital Light, for which they cravingly wander about him; and doth liberally and on every fide comfort and illuftrate the Theatre of the whole World, and all its parts, even the very leaft, like an immortal and perpetual Lamp of high and unfpeakable value. The Second Heaven fhall be the Starry Heaven, commonly called the Eighth Sphere, or the Firmament, wherein are all the Fixed Starrs, which according to this Opinion of *Pythagoras*, is (like as the Sun and Centre) void of all Motion, the Centre and utmoft Circumference mutually agreeing with each other in

R r r Immobility

Chrift in his Incarnation truly defcended from Heaven, and in his Afcention truly afcended into Heaven.

2 Cor. c. 12. v. 3. *Whether in the body or out of the body, I cannot tell, The Sun is King, Heart and Lamp of the World himfelf being abfolute-ly independent.)*

The Enigma of
Plato.

(a) Circa omni-
um Regem sunt
omnia. & Secun-
da circa Secun-
dum, et Tertia
circa Tertium:
Vide Theodo. de
Græc. affect. curat.
lib. 2. Scæch. lib.
de Parenth. Phi-
loso.

immobility. And the Third shall be the Emphyrean Heaven, that is the Seat of the Blessed. And in this manner we may come to explain and understand that admirable Secret, and profound Mystery enigmatically revealed by Plato to Dionysius of Syracuse: (a) All things are about the King of all things, Second things about the second, and Third things about the Third: For that God being the Centre of Spiritual things, the Sun, of Corporeal, Christ, of those that are Mixt, or made up of both, things do doubtlesse depend of that of these three Centres that is most correspondent and proportionable to them, and the Centre is ever adjudged to be the nobler and worthier place: and therefore in Animals the Heart, in Vegetables the Pith or Kernell wherein the Seed lyeth that conserveth their perpetuity, and virtually includes the whole Plant, are in the Midst, and in the Centre: and thus much shall suffice to have hinted at, since there may another occasion offer it self for a larger Explication of these things. By this Maxim the Authorities and Arguments of the Third Fourth and Fifth Classes are resolved.

It may be added withall, that even the Sun, Mercury and Venus (that is to say in respect of the Earth) are to be thought above, and not beneath the Earth it self, although in respect of the Universe, yea and also absolutely, they are below. The reason is, because in respect of the Earth they alwayes appear above its Surface: and although they do not environ it, yet by the Motion of the said Earth they behold one while one part, another while another part of its Circumference. Since therefore those things which in a Spherical Body are nearer to the Circumference and more remote from the Centre are said to be above, but those that are next adjoyning to the Centre are said to be below; it clearly followeth that whilst the Sun, Mercury and Venus are not only turned towards the Surface and Circumference of the said Earth, but are at a very great distance without it, successively turned about it, and every way have a view of it, and are very far remote from its Centre, they may, in respect of the said Earth, be said to be above it; as also on the other side, the Earth in respect of them may be said to be beneath: howbeit on the contrary, in respect of the Universe, the Earth in reality is much higher than they. And thus is salved the Authority of Ecclesiastes in many places, expressing those things that are, or are done on the Earth in these words, Which are done, or which are under the Sun, And in the same manner those words are reduced to their true Sense wherein it is said, That we are under the Sun, and under the Moon, whereupon Terrene things are expressed by the name of Sublunary.

Ecclesiæ. 1. 2. 3.
and almost ibi-
out.

* Quod sunt, vel
sunt sub sole.

The Sixth Classis threatneth a difficulty which is common as well

well to this of *Copernicus*, as to the Vulgar Opinion; so that they are both alike concerned in the solution of it: But so far as it opposeth that of *Copernicus*, its answer is easy from the First Maxim.

But that which is added in the Fourth Classe, That it followeth from this Opinion, that Hell (for that it is included by the Earth, as is commonly held) doth move circularly about the Sun, and in Heaven, and that so Hell it self will be found to be in Heaven; discover, in my judgment, nothing but Ignorance and Calumny, that insinuate the belief of their Arguments rather by a corrupt sense of the Words, than by solid Reasons taken from the bosome of the Nature of things. For in this place Heaven is no wise to be taken for Paradise, nor according to the Sense of Common Opinion, but (as hath been said above) according to the *Copernican* Hypothesis, for the subtlest and Purest Aire, far more tenuous and rare than this of ours; whereupon the Solid Bodies of the Stars, Moon, and Earth, in their Circular and Ordinary Motions, do passe thorow it, (the Sphere of Fire being by this Opinion taken away.) And as according to the Common Opinion it was no absurdity to say, That Hell being demerged in the Centre of the Earth and of the World it self, hath Heaven and Paradise above and below it, yea and on all sides of it, and that it is in the middle of all the Cœlestial Bodies (as if it were posited in a more unworthy place) so, neither in this will it be deemed an Error, if from the other System, which differeth not much from the Vulgar one, those or the like things follow as do in that. For both in that of *Copernicus*, and the Vulgar Hypothesis, Hell is supposed to be placed amongst the very dreggs of the Elements, and in the Centre of the Earth it self, for the confinement and punishment of the damned. Therefore we ought not for want of Reasons to trifle away time in vain and impertinent strife about words, since their true Sense is clouded then with no obscurity, and in regard that it is very clear to any man indued with a refined Intellect, and that hath but an indifferent judgment in the Liberal Arts, and especially in the Mathematicks, that the same, (or not very different Consequences do flow from both these Opinions.

By these Maxims and their Interpretations it appears, that the *Pythagorick* and *Copernican* Opinion is so probable, that its possible it may exceed even the *Ptolemaick* in probability; and since there may be deduced from it a most ordinate System, and a most admirable, and mysterious Hypothesis of the World than from that of *Ptolemy*: the Authorities of Sacred Scripture and Theological Tenents in the mean while not opposing it, being opportunely and appositely (as I have shown how they may

Heaven according to *Copernicus* is the same with the most tenuous *Aether*; but different from Paradise, which surpasseth all the Heavens.

R r 2

bc)

be) reconciled with it : And since that by it not only the Phenomena of all the Cœlestial Bodies are most readily salved, but also many Natural Reasons are discovered, which could not otherwise, (but with extream difficulty) have been found out : And since it, last of all, doth open a more easy way into Astronomy and Philosophy, and rejecteth all those superfluous and imaginary inventions produced by Astronomers to the end only, that they might be able by them to render a reason of the so many and so various Motions of the Cœlestial Orbs.

And who knows, but that in that admirable composure of the Candlestick which was to be placed in the Tabernacle of God, he might out of his extraordinary love to us have been pleased to shaddow forth unto us the Systeme of the Universe, and more especially of the Planets? (a) Thou shalt make a Candlestick of pure Gold, (saith the Text;) of beaten work shall it be made: his Shaft, and his Branches, his Bowls, his Knops, and his Flowers (b) shall be of the same. Here are five things described, the Shaft of the Candlestick in the midle, the Branches on the sides, the Bowls, the Knops and the Flowers. And since there can be no more Shafts but one, the Branches are immediatly described in these (c) words: Six Branches shall come out of the sides of it: three Branches out of the one side, and three Branches out of the other side: Happly these six Branches may point out to us six (d) Heavens, which are moved about the Sun in this order; Saturn, the slowest and most remote of all, finisheth his course about the Sun thorow all the twelve Signes of the Zodiack in thirty Years: Jupiter, being nearer than he, in twelve Years: Mars, being yet nearer than him, in two Years: The Earth, which is still nearer than he, doth perform the same Revolution, together with the Orbe of the Moon, in the space of a Year, that is in Twelve Months: Venus, which is yet nearer than all these, in (e) 9 Months: And last of all Mercury, whose vicinity to the Sun is the greatest of all, accomplisheth its whole conversion about the Sun in eighty Days. After the description of the six Branches, the sacred Text proceeds to the description of the Bowls, the Knops, and the Flowers, saying, (f) Three Bowls made like unto Almonds, with a Knop and a Flower in one Branch; and three Bowls made like Almonds in the other Branch, with a Knop and a Flower: this shall be the work of the six Branches that come out of the Shaft. And in the Candlestick shall be four Bowls made like unto Almonds, with their Knops and their Flowers: there shall be a knop under two branches of the same; and a Knop under two Branches of the same, and a Knop under two Branches of the same; which together are six Branches, proceeding from one Shaft. The truth is, the shallownesse of my understanding cannot fathome the depth

(a) Exod. 25. 31.

(b) My Author following the vulgar Translation, which hath an Elegance in some things beyond ours, cites the words thus, Facies Candelabrum ductile de auro mundissima, Hastile ejus, & Calamos, & sphaerulas, ac Lilia, ex ipso procedentia.

(c) verse 12.

(d) or Spheres.

(e) Though our Author speaketh here positively of nine Months, &c. Fathers are not agreed about the period of this planet, nor that of Mercury, as you may see at large in Ricciolus, Almagest. nov. Tom. I. part 1. l. 7. sect. 3. cha. 11. num. 11. page 627. where he maketh Venus to consume her Revolution in near 225 dayes, or 7½ Mon. and Mercury in about 88 dayes, or 3 Months: in which he followeth Kepler in his epitome Astro-

nom. p. 76c.

(f) vers. 33, 34.

depth of all the Mysteries that are couched in this most wise disposure of things: neverthelesse being amazed, and transported with admiration, I will say; Who knows but that those three Bowls like unto Almonds to be represented on each of the Branches of the Candlestick may signifie those Globes which are apter (as is this our Earth) for the receiving than emitting of Influences? Perhaps also they denote those Globes of late discovered by the help of the Optick Telescope, which participate with Saturn, Jupiter, Venus, and possibly also with the other Planets? Who knows likewise, but that there may be some occult proportion between these Globes and those Mysterious Knops and Lilies insinuated unto us in the sacred Scriptures? But this shall here suffice to bound humane Presumption, and to teach us to exspect with an Harpocratick silence from Time, the Indice of Truth, a discovery of these Mysteries: (g) Solomon made ten Candlesticks by the same Patern of Moses, which he placed, five on one hand and five on another, in the Temple erected by him in honour of the most High God; which very thing doth also, in honour of the most High God; which very thing doth also, without all question, contain most abstruse significations. Moreover, that Apple of the Knowledge of Good and Evil prohibited our first Parents by God is not without a Mystery; which some say was an Indian Figg. In which these things are to be observed: First, That it is replete with many Kernels, every one of which hath a particular Centre. Secondly, Though of it self it be hard and solid, yet about its Circumference it is of a more rare and tenuouse substance; herein resembling the Earth, which though in its Centre, and those parts which are nearest to it, it be stony, Metallick, and compact, yet the nearer one approacheth to the Circumference, its parts are seen to be the more rare and tenuouse: and withall it hath another body, more rare than its own, namely the Water, above which there is yet another, more subtil than all the rest of inferiour Bodyes, that is to say, the Aire,

The same Representation with that of the Indian Figg is held forth to us by the *Malum Punicum*, or Pomegranate, with its innumerable polycentrick Stones or Kernels, all which in the parts more remote from their Centre, and nearer approaching towards the Circumference, are of a substance so subtil and rare, that being but lightly compressed, they in a manner wholly convert into a most tenuouse Liquor or juice: Of which fruit it pleased Divine Wisdom to make mention, and ordained that its Figure should be imbroidered and wrought with a needle in the sacerdotal Garment of Aaron: (h) Beneath (saith God) upon the hem of it thou shalt make Pomegranates of blew, and of purple, and of scarlet, round about the border thereof; and Bells of gold between them round

(g) 1 Kings c. 7.
v. 49. 2 Chron. 6.
4. vers. 7.

(h) Exod. 28. 33;
34. & 39. v. 24;
25, 26.

round about: a golden bell and a pomegranate, a golden bell and a pomegranate, upon the hem of the Robe round about. And that this was a Mystical Representation of the Worlds Effigies, is averred by Solomon, saying; (i) For in the long (k) Garment, that he had on was the (l) whole World; and in the foure rows of the stones was the Glory of the Fathers graven, and thy Majesty in the Diadem of his Head.

(i) Sap. c. 18. v.

24.

(k) Exod. c. 28.

v. 6, 9, 17, 36.

(l) Or, totus Or-

bis Terrarum, as

the vulgar Trans-

lation hath it.

The same likewise is signified to us by the Grape, and in like manner by all other Fruits; but especially the Figg, Grape, and Pomegranate: whence these three are almost alwayes placed together in the Sacred Scriptures. So Numb. 20. the People of Israel complain against Moses and Aaron: (m) *h*erefore have you made us to come up out of Egypt, to bring us into this evil place, where there can grow no Seed, neither is there either Figgs, or Vines, or Pomegranates? Intimating that these kinds of Fruits were preferred by them for their excellency, before all others. And in Joel (n) *T*he Vine is dried up, and the Figg-tree languisheth, the Pomegranate-tree, the Palm-tree also, and the Apple-tree, even all the Trees of the field are withered, because joy is withered away from the Sons of Men. Likewise in Haggai: (o) *I*s the seed yet in the Bud? and hath as yet the Vine and the Figg-tree, and the Pomegranate, and the Olive-tree brought forth? In like manner in Deuteronomie the Land of Promise is commended to be (p) *A* Land of Wheat, and Barly, and Vines in which grow, Figg-trees, and Pomegranates, and Olive-trees, &c. And in the Structure of the Temple undertaken by Solomon upon Divine Inspiration the (q) Chapters of the Pillars were adorned with several rowes of Pomegranates: which particular is mentioned, not in one but many places of Holy Writ. Yea and sometimes accidentally and occasionally the Holy hath Ghost anigmatically represented this most admirable and Most Wise Structure of the World, the Order of the Heavens, and the disposure of Creatures Spiritual and Corporeal by Emblems, Parables, and Figures, least they should be as it were dazled and blinded, by the resplendent splendor of so excellent an Object. Hence we see, that in these Doctrinal & Dubious Points we may discourse in such manner by help of the Holy Scripture as is meet for the understanding of the Prophets; which seeing they are very obscure, they shall be fully understood, and may be aptly applied only then when they shall be fulfilled; and not before: So also when once the true Systeme of the Universe is found out, then, and not till then, the meaning of these Figures, and Enigma's shall be made known unto us: Thus before the coming of the Son of God had discovered unto us the Mystery of the Holy Trinity, none were able to comprehend or imagine what was concealed under those words

(m) Numb. c. 20.
v. 5.

(n) Joel c. 1. v. 12.

(o) Hagg. c. 2.
v. 19.

(p) Deut. c. 8. v. 8.

(q) 1 Kings c. 7.
v. 20. & 2 Kings
c. 15. v. 17. &
2 Chron. c. 3. v. 15,
16, & c. 4. v. 12,
13. & Jerem. c.
52. v. 21, 22.

words; (r) *In Principio creavit Elobim Cælum & Terram*: for that they did not see how the Noun Plural *Elobim* (which is as much as to say *Dij*, [Gods] should be joyned with the Verb Singular, *Creavit*: But the Mystery of the Unity of Essence and Trinity of Persons in God being revealed, it was presently known, that the Singular Number, *Creavit*, had reference to the Unity of Essence, (in regard that the Works of the Trinity *ad extra* are indivisible) and the Plural, *Elobim*, to the Persons. Who, I pray, in elder times could have found out this Mystery? And thus the Name of God is thrice repeated in *Psal. 67.* (s) *God, even our God shall blesse us, God shall blesse us, &c.* Which at first might seem a Pleonastine, and superfluous repetition; but afterwards it was evident that *David* did there set out the Benedictions of several Persons implied, to wit, the Father, Son, and Holy Ghost. Innumerable Examples of the like kind may be found in the Sacred Leaves. Therefore, to conclude, I will say with **David*, *Psal. 92. Oh Lord how glorious are thy Works! thy thoughts are very deep: an unwise man knoweth not, and a fool doth not understand these things.*

These are the particulars that I have thought fit to offer, as a Divine, concerning the not-improbable Opinion of the Mobility of the Earth and Stability of the Sun: which I hope will be acceptable to you, Reverend Sir, out of the love and diligence wherewith you pursue Virtue and Learning. But (to the end that you may also receive an account of my other Studies) I hope very shortly to publish in Print my Second Tome **Of the Institutions of all Learnings*, which shall containe all the Liberall Arts, as I have already signified in that *Syntax*, and *Spicimen* by me heretofore put forth, and published under your Name. The other five following Tomes by me promised (which shall treat of Philosophy and Theology) are not altogether so forward, nevertheless they will be speedily finished. In the mean time there will come forth my Book *Concerning* **Oracles*, now finished, together with a *Treatise* **Of Artificial Divination*. And for a pledge thereof, I send you at this time annexed to this Epistle a *Traët* **Concerning Natural Cosmological Divination*, or of Natural Prognosticks, and Presages of the Changes of Weather, and other things which fall within the compasse of Nature. God grant you all Happinesse.

Most Reverend Sir

NAPLES, from the Covent
of the Carmelites, Jan.
6. 1615.

Your Most Humble Servant

PAOLO ANTONIO FOSCARINI

FINIS;

(r) Gen. c. 1. v. 1.

(s) Psal. 67. v. 6

* Psal. 92. v. 5, 6

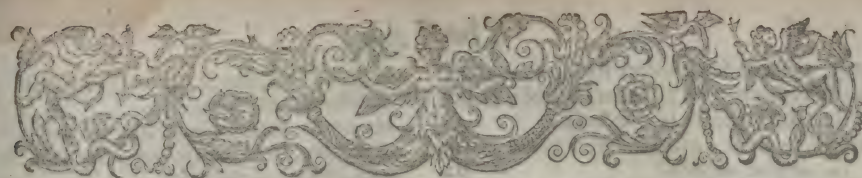
* *Institutionum
omnium Doctri-
narum.*

* *De Oraculis.*

* *De Divinatione
artificiosa.*

* *De Divinatione
Naturali Cosmo-
logica.*

Imprimatur, P. ANT. GHIBERT, Vic. Gen.
JOANNES LONGUS *Can. & Cur. Archiep.*
Neap. THEOL. Vedit.



A
T A B L E
 Of the most Observable
PERSONS and MATTERS
 Mentioned in the FIRST PART of
The First Tome.

A

A B S T R A C T.

THings are exactly the same in *Abstract*, as
 in *Concrete*. 185

A I R E.

The part of the *Aire* inferiour to the Higher
 Mountains doth follow the Motion of the
 Earth. 124

The motion of the *Aire* apt to carry with it
 light things, but not heavy. 124

The *Aire* always touching us with the same
 part of it, cannot make us feel it. 228

It is more reasonable that the *Aire* be commoved
 by the rugged surface of the Earth, than by
 the Celestial Motion. 400

It is demonstrated, inverting the Argument,
 that the perpetual Motion of the *Aire* from
 East to West, cometh from the Motion
 of Heaven. 403

A N I M A L S.

Animals, Vide, The Motion of *Animals*.

The cause of the Weariness that attends the
 Motion of *Animals*. 244

A P O L L O N I U S.

Apollonius and Copernicus demonstrate the Re-
 trogradations of Venus and Mercury. 311

Arguing, Arguments, & Argumentations
 Some in *Arguing* fix in their minds the Conclu-
 sion believed by them, and then adapt their
 Reasons to that. 250
 One

One single Experiment or sound Demonstrati-
 on, overthroweth all *Arguments* meerly pro-
 bable. 105

A pleasant Example shewing the invalidity of
 some *Phisical Argumentations*. 363

A R I S T A R C H U S.

Reason and Discourse in *Aristarchus* and Coper-
 nicus prevailed over manifest Sense. 301

A R I S T O T L E.

Aristotle maketh the World perfect, because it
 hath the Threefold Dimension. 2

Arist. his Demonstrations to prove the Worlds
 Dimensions to be three, and no more. 2

Aristotle his Definition of Nature either imper-
 fect or unseasonable. 7

Aristotle accomodates the Rules of Architecture
 to the Frame of the World, and not the
 Frame to the Rules. 8

Aristotle cannot equivocate, being the Inventer
 of Logick. 23

Aristotle his Paralogisme in proving the Earth
 to be in the centre of the World. 24

Arist. Paralogisme another way discovered. 24

Aristotle his Discourse to prove the Incorrupti-
 bility of Heaven. 26

Aristotle proveth that Circular Motion hath no
 Contrary. 26

Aristotle defective in assigning the Causes, why
 the Elements are Generable and Corrup-
 tible. 31

Aristotle would change his opinion, did he see
 the Novelties of our Age. 37

[Hbb]

Arist.

The Table.

Arist. preferres Sense before Ratiocination. 42
Aristotle affirmeth the Heavens alterable, rather
 then otherwise, by his Doctrine. 42
 Requisites to fit a man to Philosophate well in
 the way of *Aristotle*. 92
 Some of *Aristotles* Sectators impaire his Repu-
 tation, in going about to enhance it. 93
 The servile Spirit of some of *Arist.* followers. 95
 Too close an adherence to *Aristotle* is blame-
 able. 95
Aristotle and *Ptolomy* argue against the Diurnal
 Motion ascribed to the Earth. 97
 A Proposition that *Aristotle* filched from the
 Ancients, and somewhat altered. 99
Aristotle his Arguments for the Earths Quie-
 scence and Immobility. 107
Aristotle were he alive, would either refute his
 Adversaries Arguments, or else would alter
 his Opinion. 113
Aristotles first Argument against the Earths Mo-
 tion, is defective in two things. 121
 The Paralogisme of *Aristotle* and *Ptolomy* in
 supposing that for known, which is in que-
 stion. 121
Aristotle admitteth that the Fire moveth direct-
 ly upwards by Nature, and round about, by
 Participation. 122
Aristotle and *Ptolomy* seem to confute the Earths
 Mobility against those who think that it, ha-
 ving along time stood still, began to move in
 the time of *Pythagoras*. 168
Aristotle his error in affirming falling Grave
 Bodies to move according to the proportion
 of their gravities. 199
Aristotle his Demonstrations to prove the Earth
 is finite, are all nullified, by denying it to
 be moveable. 294
Aristotle maketh that Point to be the Centre of
 the Universe, about which all the Celestial
 Spheres do revolve. 294
 A question is put, if *Arist.* were forced to receive
 one of two Propositions, that make against
 his Doctrine, which he would admit. 294
Aristotle his Argument against the Ancients,
 who held that the Earth was a Planet. 344
Aristotle taxeth *Plato* of being over-studious of
 Geometry. 361
Aristotle holdeth those Effects to be miraculous,
 of which the Causes are unknown. 384

ASTRONOMERS.

Astronomers confuted by Anti-Tycho. 38
 The principal Scope of *Astronomers* is to give
 a reason of Appearances and Phenomena. 308
Astronomers all agree that the greater Magni-
 tudes.

tudes of the Orbes is the cause of the tardity
 in their Conversions. 331
Astronomers perhaps have not known what
 Appearances ought to follow, upon the An-
 nual Motion of the Earth. 338
Astronomers having omitted to instance what al-
 terations those are, that may be derived
 from the Annual Motion of the Earth, do
 thereby testifie that they never rightly un-
 derstood the same. 343

ASTRONOMICAL.

Astronomical Observations wrested by Anti-Ty-
 cho to his own purpose. 39
Astronomical Instruments are very subject to
 error. 262

ASTRONOMY.

Astronomy restored by *Copernicus* upon the
 Suppositions of *Ptolomy* 308
 Many things may remain as yet unobserved in
Astronomy 415

AUCUPATORIAN.

An *Aucupatorian* Problem for shooting of Birds
 flying. 157

AXIOME, or Axiomes.

In the *Axiome*, *Frustra fit per plura, &c.* the addi-
 tion of *æque bene* is superfluous. 106
 Three *Axiomes* that are supposed manifest. 230
 Certain *Axiomes* commonly admitted by all
 Philosophers. 361

B

BODY and Bodies.

Contraries that corrupt, reside not in the same
 Body that corrupteth. 30
 GRAVE BODY; If the Celestial Globe were
 perforated, a Grave Body descending by that
 Bore, would passe and ascend as far beyond
 the Centre, as it did descend. 203
 The motion of Grave Bodies, Vide Motion.
 The Acceleration of Grave Bodies that descend
 naturally, increaseth from moment to
 moment. 205
 We know no more who moveth Grave Bodies
 downwards, than who moveth the Stars
 round; nor know we any thing of these
 Courses

The Table.

Courses, more than the Names imposed on them by our selves. 210
 The great Masse of *Grave Bodies* being transferred out of their Place, the seperated parts would follow that Masse. 221
 PENSILE BODY; Every *Pensile Body* carried round in the Circumference of a Circle, acquireth of it self a Motion in it self contrary to the same. 362
 CELESTIAL BODIES neither heavy nor light according to *Aristotle*. 23
Celestial Bodies are Generable and Corruptible because they are Ingenerable and Incorruptible. 29
 Amongst *Celest*, *Bodies* there is no contrariety. 29
Celestial Bodies touch, but are not touched by the Elements. 30
 Rarity and Density in *Celestial Bodies*, different from Rarity and Density in the Elements. 30
Celestial Bodies designed to serve the Earth, need no more but Motion and Light. 45
Celestial Bodies wantan interchangeable Operation on each other. 46
Celestial Bodies alterable in their externe parts. 46
 Perfect Sphericity why ascribed to *Celestial Bodies* by Peripateticks. 69
 All *Celestial Bodies* have Gravity and Levity. 493
 ELEMENTARY BODIES; Their propension to follow the Earth, hath a limited Sphere of Activity. 213
 LIGHT BODIES easier to be moved than heavy, but lesse apt to conserve the Motion. 400
 LUMINOUS BODIES; *Bodies* naturally *Luminous* are different from those that are by nature Obscure. 34
 The reason why *Luminous Bodies* appear so much the more enlarged, by how much they are lesser. 304
 Manifest Experience shews that the more *Luminous Bodies* do much more irradiate than the lesse Lucid. 306
 SIMPLE BODIES have but one Simple Motion that agreeth with them. 494
 SPHERICAL BODIES; In *Spherical Bodies* *Deorsum* is the Centre, and *Sursum* the Circumference. 479

BONES.

The ends of the *Bones* are rotund, and why. 232

BUONARRUOTTI.

Buonarruotti a Statuary of admirable ingenuity. 86

C A.

C

CANON.

A shameful Errour in the Argument taken from the *Canon*-Bullets falling from the Moons Concave. 197

An exact Computation of the fall of the *Canon*-Bullet from the Moons Concave, to the Centre of the Earth. 198

CELESTIAL

Celestial Substances that be Unalterable, and Elementary that be Alterable, necessary in the opinion of *Aristotle*. 2

CENTRE.

The Sun more probably in the Centre of the Universe, than the Earth. 22

Natural inclination of all the Globes of the World to go to their Centre. 22

Grave Bodies may more rationally be affirmed to tend towards the Centre of the Earth, than of the Universe. 25

CHYMISTS.

Chymists interpret the Fables of Poets to be Secrets for making of Gold. 93

CIRCLE, and Circular.

It is not impossible with the Circumference of a small Circle few times revolved, to measure and describe a line bigger than any great Circle whatsoever. 222

The Circular Line perfect, according to *Aristotle*, and the Right imperfect, and why. 9

CLARAMONTIUS.

The Paralogisme of *Claramontius*. 241

The Argument of *Claramontius* recoileth upon himself. 245

The Method observed by *Claramontius* in confuting Astronomers, and by *Salviatus* in refuting him. 253

CLOUDS.

Clouds no lesse apt than the Moon to be illuminated by the Sun. 73

C O N

The Table.

CONCLUSION and Conclusions.

The certainty of the *Conclusion* helpeth by a resolute Method to finde the Demonstration. 37
The Book of *Conclusions*, frequently mentioned, was writ by Christopher Scheiner a Jesuit. 195, & 323.

CONTRARIES.

Contraries that corrupt, reside not in the same Body that corrupteth. 30

COPERNICAN.

Answers to the three first Objections against the *Copernican System*. 303
The *Copernican System* difficult to be understood, but easie to be effected. 354
A plain Scheme representing the *Copernican System* and its consequences. 354
The prohibiting of the *Copernican Doctrine*, after so long a Toleration, and now that it is more than ever followed, studied and confirmed, would be an affront to Truth. 444
The *Copern. System* admirably agreeth with the Miracle of *Josuah* in the Literal Sense. 456
If Divines would admit of the *Copernican System*, they might soon find out Expositions for all Scriptures that seem to make against it. 459
The *Copernican System* rejected by many, out of a devout respect to Scripture Authorities. 461
The *Copernican System* more plainly asserted in Scripture than the *Ptolomaick*. 469

COPERNICANS.

Copernicans are not moved through ignorance of the Arguments on the Adverse part. 110
Copernicans were all first against that Opinion, but the Peripateticks were never on the other side. 110
Copernicans too freely admit certain Propositions for true, which are doubtful. 159
He that will be a *Copernican* must deny his Senses. 228
A Great Mathematician made a *Copernican*, by looking into that Doctrine, with a purpose to confute it. 443

COPERNICUS.

Copernicus esteemeth the Earth a Globe, like to a Planet. 1
Objections of two Moderne Authours [Scheiner and Claramontius] against *Copernicus*. 195
Copernicus

Copernicus his Opinion overthrowes the *Criterion* of Phylosophers. 223

A grosse Errour in the Opposer of *Copernicus*, and wherein it appears. 234, 235, & 236

A subtle and withal simple Argument against *Copernicus*. 234

Copernicus his Opponent had but little studied him, as appears by another grosse Errour. 235

Its questioned whether he understood the third Motion assigned to the Earth by *Copern.* 236

Copernicus erroneously assigns the same Operations to different Natures. 238

A declaration of the improbability of *Copernicus* his Opinion. 301

Reason and Discourse in *Copernicus* and Aristarchus prevailed over Sense. 301

Copernicus speaketh nothing of the small Variation of Bignesse in Venus and Mars. 302

Copernicus perswaded by Reasons contrary to Sensible Experiments. 306

Copernicus restored Astronomy upon the Suppositions of Ptolomy. 308

What moved *Copernicus* to establish his System. 308

Its a great argument in favour of *Copernicus*, that he obviates the Stations and Retrogradations of the Motions of the Planets. 309

Instances Ironically propounded by Scheiner against *Copernicus*. 323

Copernicus understood not some things for want of Instruments. 338

The grand difficulty in *Copernicus* his Doctrine, is that which concerns the Phenomena of the Sun and fixed Stars. 343

Copernicus the Restorer of the Pythagorean Hypothesis, and the Occasion of it. 429

Copernicus founded not his Doctrine on Reasons depending on Scripture, wherein he might have mistaken their Sense, but upon Natural Conclusions and Astronomical and Geometrical Demonstrations. 431

CORRUPTIBLE, and Corruptibility.

The perfection of Figure operates in *Corruptible Bodies*, but not in Eternal. 69

The Disparagers of *Corruptibility* ought to be turned into Statues. 37

Corruptibility admits of more and lesse, so doth not Incorruptibility. 69

COUNCILS.

The Councils refuse to impose Natural Conclusions as matters of Faith. 450

DIA

The Table.

D

DIAMONDS.

Diamonds ground to divers fides, and why. 63

DIDACUS.

Didacus à Stunica reconcileth Texts of Scripture with the Copernican Hypothesis. 468

DEFINITIONS.

Definitions contain virtually all the Passions of the things defined. 87

E

EARTH.

The *Earth* Spherical by the Conspiracy of its parts to go to its Centre. 21

It is easier to prove the *Earth* to move, than that Corruptibility is made by Contraries. 27

The *Earth* very Noble, by reason of the Mutations made therein. 45

The *Earth* unprofitable and full of Idleness, its Alterations being taken away. 45

The *Earth* more Noble than Gold and Jewels. 45

The Celestial Bodies designed to serve the *Earth*, need no more but Motion and Light. 45

The Generations and Mutations that are in the *Earth*, are all for the Good of Man. 47

From the *Earth* we see more than half the Lunar Globe. 51

Seven Resemblances between the *Earth* and Moon. 48 to 53

The *Earth* unable to reflect the Suns Rays. 54

The *Earth* may reciprocally operate on Celestial Bodies with its Light. 80

Affinity between the *Earth* and Moon, by reason of their Vicinity. 81

The Motions of the *Earth* imperceptible to its Inhabitants. 97

The *Earth* can have no other Motions than those which to us appear commune to all the rest of the Universe, the *Earth* excepted. 97

The Diurnal Motion seemeth commune to all the Universe, the *Earth* onely excepted. 97

Aristotle and Ptolomy argue against the *Earth* Diurnal Motion. 97

The Diurnal Motion of the *Earth*. Vide *Diurnal Motion*.

Seven Arguments to prove the Diurnal Motion

on to belong to the *Earth*. 99 to 103

The *Earth* a pendent Body, and equilibrated in a fluid Medium, seems unable to resist the Rapture of the Diurnal Motion. 103

Two kinds of Arguments against the *Earth* Motion. 108

Arguments of Aristotle, Ptolomy, Tycho, and other persons, against the *Earth* Motion. 107 & 108

The first Argument against the *Earth* Motion taken from Grave Bodies falling from on high to the Ground. 108

Which Argument is confirmed by the Experiment of a Body let fall from the Round-top of a Ships Mast. 108

The second Argument taken from a Project shot very high. 108

The third Argument taken from the Shot of a Canon towards the East, and towards the West. 108

This Argument is confirmed by two Shots towards the North and South, and two others towards the East and West. 109

The fourth Argument taken from the Clouds and from Birds. 112

A fifth Argument taken from the Aire which we feel beat upon us when we run an Horse at full speed. 114

A sixth Argument taken from the whirling of Circular Bodies, which hath a faculty to extrude and dissipate. 114

The Answer to Aristotles first Argument. 115

The Answer to the second Argument. 117

The Answer to the third Argument. 120 to 150

An Instance of the Diurnal Motion of the *Earth*, taken from the Shot of a Piece of Ordinance perpendicularly, and the Answers to the same, shewing the Equivoke. 153, 154

The Answer to the Argument of the Shots of Canons made towards the North and South. 158

The Answer to the Argument taken from the Shots at point blank towards the East and West. 159

The Answer to the Argument of the flying of Birds contrary to the Motion of the *Earth*. 165

An Experiment by which alone is shewn the Nullity of all the Arguments produced against the Motion of the *Earth*. 165

The Stupidity of some that think the *Earth* began to move, when Pythagoras began to affirm that it did so. 167

A Geometrical Demonstration to prove the Impossibility of Extrusion, by means of the *Earth* Vertigo, in Answer to the sixth

[iii]

The Table.

Argument.	176	The Axis of the <i>Earth</i> continueth alwayes parallel to it self, and describeth a Cylindrical Superficies, inclining to the Orb.	344
Granting the Diurnal Vertigo of the <i>Earth</i> , and that by some sudden Stop or Obstacle it were Arrested, Houses, Mountains themselves, and perhaps the whole Globe, would be shaken in pieces.	190	The Orb of the <i>Earth</i> never inclineth, but is immutably the same.	345
Other Arguments of two Modern Authours [Scheiner and. Claramontius] against the Copernican Hypothesis of the <i>Earths</i> Motion.	195	The <i>Earth</i> approacheth or recedeth from the fixed Stars of the Ecliptick the quantity of the Grand Orb.	349
The first Objection of the Modern Authour [Scheiner] in his Book of Conclusions.	195	If in the fixed Stars one should discover any Mutation, the Motion of the <i>Earth</i> would be undeniable.	351
The Argument of [Claramontius] against the <i>Earths</i> Motion, taken from things falling perpendicularly, another way answered.	223	Necessary Propositions for the better conceiving of the Consequences of the <i>Earths</i> Motion.	354
The <i>Earths</i> Motion collected from the Stars.	229	An admirable Accident depending on the not inclining of the <i>Earth</i> Axis.	358
Arguments against the <i>Earths</i> Motion, taken <i>ex rerum natura</i> .	230	Four several Motions assigned to the <i>Earth</i> .	362
A Simple Body as the <i>Earth</i> , cannot move with three several Motions.	231	The third Motion ascribed to the <i>Earth</i> , is rather a resting immoveable.	363
The <i>Earth</i> cannot move with any of the Motions assigned it by Copernicus.	231	An admirable interne vertue [or faculty] of the <i>Earths</i> Globe, to behold alwayes the same part of Heaven.	363
Answers to the Arguments against the <i>Earths</i> Motion, taken <i>ex rerum natura</i> .	231	Nature, as in sport, maketh the Ebbing and Flowing of the Sea to prove the <i>Earths</i> Mobility.	379
Four Axiomes against the Motion of the <i>Earth</i> .	230 to 232	All Terrene Effects indifferently confirm the Motion or Rest of the <i>Earth</i> , except the Ebbing and Flowing of the Sea.	380
One onely Principle might cause a Plurality of Motions in the <i>Earth</i> .	233	The Cavities of the <i>Earth</i> cannot approach or recede from the Centre of the same.	387
The same Argument against the Plurality of Motions in the <i>Earth</i> , answered by Examples of the like Motions in other Celestial Bodies.	236	The Hypothesis of the <i>Earths</i> Mobility taken in favour of the Ebbing and Flowing opposed.	399
A fourth Argument [of Claramontius] against the Copernican Hypothesis of the <i>Earths</i> Mobility.	239	The Answers to those Objections made against the <i>Earths</i> Motion.	399
From the <i>Earths</i> obscurity, and the splendor of the fixed Stars, it is argued that it is moveable, and they immoveable.	239	The Revolution of the <i>Earth</i> confirmed by a new Argument taken from the Air.	400
A fifth Argument [of Claramontius] against the Copernican Hypothesis of the <i>Earths</i> Mobility.	240	The vaporous parts of the <i>Earth</i> partake of its Motions.	400
Another difference between the <i>Earth</i> and Celestial Bodies, taken from Purity and impurity.	240	Another observation taken from the Ayr, in confirmation of the motion of the <i>Earth</i> .	402
It seems a Solecisme, to affirme that the <i>Earth</i> is not in Heaven.	241	A Reason of the continual Motion of the Air and Water may be given by making the <i>Earth</i> moveable, rather then by making it immoveable.	405
Granting to the <i>Earth</i> the Annual, it must of necessity also have the Diurnal Motion assigned to it.	300	The <i>Earths</i> Mobility held by sundry great Philosophers amongst the Antients.	437 & 468
Discourses more than childish, that serve to keep Fools in the Opinion of the <i>Earths</i> Stability.	301	The Fathers agree not in expounding the Texts of Scripture that are alledged against the <i>Earths</i> Mobility.	450
The Difficulties removed that arise from the <i>Earths</i> moving about the Sun, not solitarily, but in consort with the Moon.	307	The <i>Earth</i> Mobility defended by many amongst the Modern Writers.	478
The		The <i>Earth</i> shall stand still after the Day of Judgement.	480
		The <i>Earth</i> is another Moon or Star.	486
		The <i>Earths</i> several Motions, according to Copernicus.	

The Table.

pernicious. 491
 The Earth *secundum totum* is Immutable, though
 not Immoveable. 491
 The Earths Natural Place. 492
 The Earths Centre keepeth her in her Natural
 Place. 493
 The Earth, in what Sense it may *absolutely* be said
 to be in the lowest part of the World. 496

EBBING and Ebbings.

The first general Conclusion of the impossibi-
 lity of *Ebbing* and Flowing the Immobility of
 the Terrestrial Globe being granted. 380
 The Periods of *Ebbings* and Flowings, Diurnal,
 Monthly, and Annual. 381
 Varieties that happen in the Diurnal Period of
 the *Ebbings* and Flowings. 382
 The Causes of *Ebbings* and Flowings alledged
 by a Modern Philosopher. 382
 The Cause of the *Ebbing* and Flowing ascribed
 to the Moon by a certain Prelate. 383
 The Cause of the *Ebbings*, &c. referred by Hye-
 ronimus Borrius and other Peripateticks, to
 the temperate heat of the Moon. 383
 Answer to the Vanities alledged as Causes of
 the *Ebbing* and Flowing. 383
 Its proved impossible that there should natu-
 rally be any *Ebbing* and Flowing, the Earth
 being immoveable. 386
 The most potent and primary Cause of the *Eb-*
bing and Flowing. 390
 Sundry accidents that happen in the *Ebbings*
 and Flowings. 391
 Reasons renewed of the particular Accidents
 observed in the *Ebbings* and Flowings. 393
 Second Causes why in several Seas and Lakes
 there are no *Ebbings* and Flowings. 394
 The Reason why the *Ebbings* and Flowings for
 the most part, are every Six Hours. 395
 The Cause why some Seas though very long,
 suffer no *Ebbing* and Flowing. 395
Ebbings and Flowings, why greatest in the Ex-
 tremities of Gulphs, and least in the middle
 parts. 396
 A Discussion of some more Abstruse Accidents
 observed in the *Ebbing* and Flowings. 396
 The *Ebbing* and Flowing may depend on the Di-
 urnal Motion of Heaven. 404
 The *Ebbing* and Flowing cannot depend on the
 Motion of Heaven. 405
 The Causes of the Periods of the *Ebbings* and
 Flowings Monthly and Annual, at large
 assigned. 407
 The Monthly and Annual alterations of the
Ebbings and Flowings, can depend on no-
 thing,

thing, save on the alteration of the Additions
 and Subtractions of the Diurnal Period from
 the Annual. 408
 Three ways of altering the proportion of the
 Additions of the Diurnal Revolution, to
 the Annual Motion of the *Ebbing* and Flow-
 ing. 409
Ebbings and Flowings are petty things, in
 comparison of the vastness of the Seas, and
 the Velocity of the Motion of the Terrestrial
 Globe. 417

EFFECT and Effects.

Of a new *Effect* its necessary that the Cause be
 likewise new. 370
 The Knowledge of the *Effects* contribute to the
 investigation of the Causes. 380
 True and Natural *Effects* follow without diffi-
 culty. 387
 Alterations in the *Effects* argue alteration in the
 Cause. 407

ELEMENTS, and their Motions, Vide MOTION.

ENCYCLOPEDIA.

Subtilties sufficiently insipid, ironically spoken,
 and taken from a certain *Encyclopedia*. 153

EXPERIMENTS.

Sensible *Experiments* are to be preferred before
 Humane Argumentations. 21, 33, 42.
 Its good to be very cautious in admitting *Ex-*
periments for true, to those that never tried
 them. 162
Experiments and Arguments against the Earths
 Motion, seem so far concluding, as they lye
 under Equivokes. 162
 The Authority of Sensible *Experiments* and ne-
 cessary Demonstrations in deciding of Phy-
 sical Controversies. 436

EYE.

The Circle of the Pupil of the Eye contracteth
 and enlargeth. 329
 How to finde the distance of the Rays Con-
 course from the Pupil of the Eye. 329

F

FAITH.

Faith more infallible than either Sense or
 Reason.

The Table.

Reason.

475

FIRE.

Fire moveth directly upwards by Nature, and round about by Participation, according to Aristotle. 122
It is improbable that the Element of *Fire* should be carried round by the Concave of the Moon. 405

FIGURE and Figures.

Figure is not the Cause of Incorruptibility, but of Longer Duration. 66
The perfection of *Figure* appeareth in Corruptible Bodies, but not in the Eternal. 69
If the Spherical *Figure* conferred Eternity, all things would be Eternal. 69
It is more difficult to finde *Figures* that touch in a part of their Surface, then in one sole point. 185
The Circular *Figure* placed amongst the *Postulata* of Mathematicians. 186
Irregular *Figures* and *Formes* difficult to be introduced. 187
Superficial figures increase in proportion double to their Lines. 304

FLEXURES.

The necessity and use of *Flexures* in Animals, for varying of their Motions. 232

FOSCARINI.

Foscarini his Reconciling of Scripture Texts with the Copernican *Hypothesis*. 473

G

GENERABILITY.

Generability and Corruptibility are onely amongst Contraries, according to Arist. 26
Generability and Alterability are greater perfections in Mundane Bodies, then the Contrary Qualities. 44

GEOMETRICAL, and Geometry.

Geometrical Demonstrations of the Triple Dimension. 4
Geometrical Exactness needlesse in Physical Proofs. 6
Aristotle taxeth Plato for being too studious of Geome-

Geometry.

334

Peripatetick Phylosophers condemning the Study of *Geometry*, and why. 461

GILBERT.

The Magnetick Phylosophy of *Will. Gilbert*. 364
The Method of *Gilbert* in his Philosophy. 367

GLOBE.

Our *Globe* would have been called Stone, instead of Earth, if that name had been given it in the beginning. 367

GOD.

God and Nature do employ themselves in caring for Men, as if they minded nothing else. 333
An Example of *Gods* care of Man-kind, taken from the Sun. 333
God hath given all things an inviolable Law to observe. 400

GREAT.

Great and Small, Immense, &c. are Relative Terms. 334

GRAVITY.

Grave; Vide *Body*.
Gravity and Levity, Rarity and Density, are contrary qualities. 30
Things *Grave* had being before the Common Centre of *Gravity*. 221
Gravity and Levity of Bodies defined. 493

GUN and Gunnery.

The Reason why a *Gun* should seem to carry farther towards the West than towards the East. 148
The Revolution of the Earth supposed, the Ball in the *Gun* erected perpendicularly, doth not move by a perpendicular, but an inclined Line. 155
It is ingenuously demonstrated, that, the Earths Motion supposed, the Shot of Great *Guns* ought to vary no more than in its Rest. 161
The Experiment of a Running Chariot to find out the difference of Ranges in *Gunnery*. 148
A Computation in *Gunnery*, how much the Ranges of Great Shot ought to vary from the Mark, the Earths Motion being Granted. 160

H F A-

The Table.

H

H E A V E N.

<i>Heaven</i> an Habitation for the Immortal Gods.	26
<i>Heavens</i> Immutability evident to Sense.	26
<i>Heaven</i> Immutible, because there never was any Mutation seen in it.	34
One cannot (saith <i>Aristotle</i>) speak confidently of <i>Heaven</i> , by reason of its great distance.	42
The substance of the <i>Heavens</i> impenetrable, according to <i>Aristotle</i> .	54
The Substance of <i>Heaven</i> Intangible.	55
Many things may be in <i>Heaven</i> , that are Invisible to us.	334
There are more Documents in the Open Book of <i>Heaven</i> , than Vulgar Wits are able to Penetrate.	444
<i>Heaven</i> and Earth ever mutually opposed to each other.	480
Which are really the Greater Lights in <i>Heaven</i> , and which the lesser.	484
<i>Heaven</i> is not composed of a fifth Essence, differing from the Matter of inferiour Bodies.	494
<i>Heaven</i> is no Solid or Dense Body, but Rare.	494
Christ at his Incarnation truly descended from <i>Heaven</i> , and at his Ascension truly ascended into <i>Heaven</i> .	496
Of the First, Second and Third <i>Heaven</i> .	497
<i>Heaven</i> in the Sense of Copernicus, is the same with the most tenuous <i>Aether</i> , but different from Paradise, which excells all the <i>Heavens</i> .	499

H E L L.

<i>Hell</i> is in the Centre of the Earth, not of the World.	480
--	-----

H E L I X.

The <i>Helix</i> about the Cylinder may be said to be a Simple Line.	7
--	---

H Y P O T H E S I S.

The true <i>Hypothesis</i> may dispatch its Revolutions in a shorter time in lesser Circles, than in greater, the which is proved by two Examples.	410
--	-----

J E S T.

I

J E S T.

A <i>Jest</i> put upon one that offered to sell a certain Secret of holding Correspondence at a Thousand Miles distance.	79
A <i>Jest</i> of a certain Statuary.	94

I M P O S S I B I L I T Y and *Impossibilities*.

Nature attempts not <i>Impossibilities</i> .	10
To seek what would follow upon an <i>Impossibility</i> is Folly.	22

I N C O R R U P T I B I L I T Y.

<i>Incarnability</i> esteemed by the Vulgar, out of their fear of Death.	45
--	----

I N F I N I T Y.

Of <i>Infinity</i> the Parts are not one greater than another, although they are comparatively unequal.	106
---	-----

I N S T R U M E N T and *Instruments*.

<i>Instruments</i> Astronomical very subject to Error.	262
Copernicus understood not some things for want of <i>Instruments</i> .	338
A proof of the small credit that is to be given to Astronomical <i>Instruments</i> in Minute Observations.	351
Ptolomy did not confide in an <i>Instrument</i> made by Archimedes.	352
<i>Instruments</i> of Tycho made with great Expence.	352
What <i>Instruments</i> are most apt for exact Observations.	352

I N V E N T O R S.

The First <i>Inventors</i> and Observers of things ought to be admired.	370
---	-----

J O S H U A H.

The Miracle of <i>Joshuah</i> in commanding the Sun to stand still, contradicts the Ptolomaick System.	456
<i>Joshuah's</i> Miracle admirably agreeth with the Pythagorick System.	457

V V V

I R O N.

The Table.

IRON.

Its proved that *Iron* consists of parts more subtil,
pure and compact than the Magnet. 370

JUPITER.

Jupiter and Saturn do encompass the Earth,
and the Sun. 258

Jupiter augments less by Irradiation, than the
Dog-Star. 305

K

KEPLER.

The Argument of *Kepler* in favour of Coper-
nicus. 242

An Explanation of the true Sense of *Kepler*, and
his Defence. 243

The feigned Answer of *Kepler* couched in an
Artificial Irony. 244

Kepler is, with respect, blamed. 422

Keplers reconciling of Scripture Texts which the
Copernican Hypothesis. 461

KNOW, &c.

The having a perfect *Knowledge* of nothing,
maketh some beleeve they understand all
things. 84

Gods manner of *Knowing* different from that of
Man. 87

The great Felicity for which they are to be en-
vied, who persuade themselves that they
Know every thing. 164

Our *Knowledge* is a kind of Reminiscence, ac-
cording to Plato. 169

L

LIGHT.

Light reflected from the Earth into the
Moon. 52

The Reflex *Light* of uneven Bodies is more uni-
versal than that of the smooth, and why. 62

The more rough Superficies make greater Re-
flection of *Light* than the less rough. 65

Perpendicular Rays of *Light* illuminate more
than the Oblique, and why. 65

The more Oblique Rays of *Light* illuminate
less, and why. 65

Light or Luminous Bodies appear the brighter
in an Obscure Ambient. 74

LINE.

LINE.

The *Right Line* and Circumference of an infi-
nite Circle are the same thing. 342

LAWYERS.

Contentious *Lawyers* that are retained in an ill
Cause, keep close to some expression fallen
from the adverse party at unawares. 324

LOOKING-GLASSES.

Flat *Looking-Glasses* cast forth their Reflection to-
wards but one place, but the Spherical eve-
ry way. 39

LYNCEAN.

The *Lyncean* Academick the first Discoverer of
the Solar spots, and all the other Celestial
Novelties. 312

The History of his proceedings for a long
time, about the Observation of the Solar
Spots. 312

M

MAGNET.

Many properties in the *Magnet*. 367

The *Magnet* armed takes up more Iron, than
when unarmed. 369

The true cause of the Multiplication of Vertue
in the *Magnet*, by means of the Arming. 370

A sensible proof of the Impurity of the *Mag-
net*. 371

The several Natural Motions of the *Mag-
net*. 374

Philosophers are forced to confesse that the
Magnet is compounded of Celestial Substan-
ces, and of Elementary. 375

The Error of those who call the *Magnet* a mixt
Body, and the Terrestrial Globe, a simple
Body. 375

An improbable Effect admired by Gilbertus in
the *Magnet*. 376

MAGNETICK Philosophy.

The *Magnetick Philosophy* of William Gilbert. 364

MAGNITUDE.

The *Magnitude* of the Orbs and the Velocity
of the Motions of Planets answer proporti-
onably,

The Table.

onaby ; as if descended from the same place. 19
 Immenſe Magnitudes and Numbers are incomprehenſible by our Underſtandings. 332

MARS.

Mars neceſſarily includeth within its Orb the Earth, and alſo the Sun. 298
Mars at its Oppoſition to the Sun, ſeems ſixty times bigger than towards the Conjunction. 298
Mars makes an hot aſſault upon the Copernican Syſteme. 302

MARSILIUS.

Signor Caſar Marſilius obſerveth the Meridian to be moveable. 422

MEDICEAN.

The time of the *Medicean* Planets converſions. 101
 The *Medicean* Planets are as it were four Moons about *Jupiter*. 307

MEDITERRAN.

Mediterranean Sea made by the Separation of *Abila* and *Calpen*. 35
 The Voyages in the *Mediterran* from Eaſt to Weſt are made in ſhorter times than from Weſt to Eaſt. 403

MERCURY.

The Revolution of *Mercury* concluded to be about the Sun, within the Orb of *Venus*. 298
Mercury admitteth not of clear Obſervations. 307

MOON.

The *Moon* hath no Generation of things, like as we have, nor is it inhabited by Men. 47
 In the *Moon* may be a Generation of things different from ours. 47
 There may be Subſtances in the *Moon*, very different from ours. 48
 The firſt reſemblance between the *Moon* and Earth, which is that of Figure, is proved, by their manner of being illuminated by the Sun. 48
 The ſecond reſemblance is the *Moons* being

Opacous, as the Earth. 48
 The third reſemblance is the *Moons* being Dense and Mountainous as the Earth. 49
 The fourth reſemblance is the *Moons* being diſtinguiſhed into two different parts for Clarity and Obſcurity, as the Terreſtrial Globe into Sea and Land. 49
 The fifth reſemblance is Mutation of Figures in the Earth, like thoſe of the *Moon*, and made with the ſame Periods. 49
 All the Earth ſeeth halfe onely of the *Moon*, and halfe onely of the *Moon* ſeeth all the Earth. 51
 Two Spots in the *Moon*, by which it is perceived that She hath reſpect to the Centre of the Earth in her Motion. 52
 Light reflected from the Earth into the *Moon*. 52
 The ſixth reſemblance is that the Earth and *Moon* interchangeably illuminate. 53
 The ſeventh reſemblance is that the Earth and *Moon* interchangeably Eclipse. 53
 The Secondary Clarity of the *Moon* eſteemed to be its Native Light. 54
 The Surface of the *Moon* more ſleek then any Looking-Glaſſe. 55
 The eminencies and Cavities in the *Moon*, are illuſions of its Opacous and Perſpicuous parts. 55
 The *Moons* Surface is ſharp, as is largely proved. 57
 The *Moon*, if it were ſleek like a Spherical Looking-Glaſſe, would be inviſible. 60
 The apparent Unevenneſſes of the *Moons* Surface aptly repreſented by Mother of Pearl. 70
 The apparent Unevenneſſes of the *Moon* cannot be imitated by way of more and leſſe Opacity, and Perſpicuity. 71
 The various Aspects of the *Moon* imitable by any Opacous matter. 71
 Sundry Phenomena from whence the *Moons* Montuoſity is argued. 71
 The *Moon* appears brighter by night, than by day. 72
 The *Moon* beheld in the day time, is like to a little Cloud. 72
 Clouds are no leſſe apt than the *Moon* to be illuminated by the Sun. 73
 A Wall illuminated by the Sun, compared to the *Moon*, ſhines no leſſe than it. 73
 The third reflection of a Wall illuminates more than the firſt of the *Moon*. 74
 The Light of the *Moon* weaker than that of the Twy-light. 74
 The ſecondary Light of the *Moon* cauſed by the Sun, according to ſome. 76
 The

The Table.

The secondary Light of the <i>Moon</i> appears in form of a Ring, <i>i. e.</i> bright in the extreme Circumference, and not in the midst, and why.	77
The secondary Light of the <i>Moon</i> , how it isto be observed.	78
The <i>Moons</i> Discus in a Solar Eclipse can be seen onely by Privation.	78
Solidity of the <i>Moons</i> Globe argued from its being Mountainous.	81
The secondary Light of the <i>Moon</i> clearer before the Conjunction than after.	82
The obscurer parts of the <i>Moon</i> are Plains, and the more bright Mountains.	83
Long Ledges of Mountains about the Spots of the <i>Moon</i> .	83
There are not generated in the <i>Moon</i> things like to ours, but if there be any Productions, they are very different.	83
The <i>Moon</i> not composed of Water and Earth.	83
Those Aspects of the Sun necessary for our Productions, are not so in the <i>Moon</i> .	83
Natural Days in the <i>Moon</i> are of a Moneth long.	84
To the <i>Moon</i> the Sun declineth with a difference of ten Degrees, and to the Earth of Forty seven Degrees.	84
There are no Rains in the <i>Moon</i> .	84
The <i>Moon</i> cannot sepearate from the Earth.	295
The <i>Moons</i> Orbe environeth the Earth, but not the Sun.	299
The <i>Moon</i> much disturbeth the Order of the other Planets.	362
The <i>Moons</i> Motion principally sought in the Account of Eclipses.	416
The <i>Moon</i> is an <i>Aethereal</i> Earth.	492

MOTION and Motions.

<i>Motion</i> of Projects. Vide <i>Projects</i> .	
The Conditions and Attributes which differ the Celestial and Elementary Bodies depend on the <i>Motions</i> assigned them by Aristotle.	25
Peripateticks improperly assign those <i>Motions</i> to the Elements for Natural with which they never were moved, and those for Preternatural with which they alwayes move.	33
<i>Motion</i> , as to the things that move thereby, is as if it never were, and so farre operates, as it relates to things deprived of <i>Motion</i> .	98
<i>Motion</i> cannot be made without its moveable Subject.	104
<i>Motion</i> and Rest principal Accidents in Nature.	112
Two things necessary for the perpetuating of a <i>Mo-</i>	

<i>Motion</i> ; an unlimited Space, and an incorruptible Moveable.	117
Disparity in the <i>Motions</i> of a Stone falling from the Round Top of a Ship, and from the Top of a Tower.	123
The <i>Motion</i> of grave Pendula might be perpetuated, impediments being removed.	203
Whence the <i>Motion</i> of a Cadent Body is collected.	224
The <i>Motion</i> of the Eye argueth the <i>Motion</i> of the Body looked on.	224
Different <i>Motions</i> depending on the Fluctuation of the Ship.	226
Our <i>Motion</i> may be either interne, or externe, and yet we never perceive or feel it.	229
The <i>Motion</i> of a Boat insensible to those that are within it, as to the Sense of Feeling.	229
The <i>Motion</i> of a Boat sensible to Sight joyned with Reason.	229
A simple Body, as the Earth, cannot move with three several <i>Motions</i> .	231
<i>Motion</i> and Rest are more different than Right <i>Motion</i> and Circular.	237
One may more rationally ascribe to the Earth two intern Principles to the Right and Circular <i>Motion</i> , than two to <i>Motion</i> and Rest.	237
The diversity of <i>Motions</i> helpeth us to know the Diversity of Natures.	237
Bodies of the same kind, have <i>Motions</i> that agree in kinde.	239
The greatness and smallness of the Body make a difference in <i>Motion</i> and not in Rest.	243
Every pensile and librated Body carried round in the Circumference of a Circle acquireth of it self a <i>Motion</i> in it self equal to the same.	362
Two sorts of <i>Motion</i> in the containing Vessel may make the containing Water to rise and fall.	387
An Accident in the Earths <i>Motion</i> impossible to be imitated.	392
ABSOLUTE MOTION: Things said to move according to certain of their parts, and not according to their whole, may not be said to move with an Absolute <i>Motion</i> , but per accidents.	491
ANIMAL MOTION: The Diversity of the <i>Motions</i> of Animals, depend on their Flexures.	232
The Flexures in Animals are not made for varying of their <i>Motions</i> .	232
The <i>Motions</i> of Animals are of one sort.	232
The <i>Motions</i> of Animals are all Circular.	233
Secondary <i>Motion</i> of Animals dependent on the first.	233

The Table.

Animals would not grow weary of their Motion, proceeding as that which is assigned to the Terrestrial Globe.	244	cliptick.	347
The Cause of the weariness that attends the Motion of Animals.	244	An Indice or Observation in the Fixed Stars like to that which is seen in the Planets, is an Argument of the Earths Annual Motion.	347
The Motion of an Animal is rather to be called Violent than Natural.	244	The Suns Annual Motion how it cometh to passe, according to Copernicus.	355
ANNUAL MOTION: The Annual Motion of the Earth must cause a constant and strong Winde.	228	The Annual and Diurnal Motion are consistent in the Earth.	362
The Error of the Antagonist of Copernicus is manifest, in that he declareth that the Annual and Diurnal Motion belonging to the Earth, are both oneway, and not contrary.	235	Three wayes of altering the proportion of the Additions of the Diurnal Revolution to the Annual Motion.	409
The Annual Motion of the Earth mixing with the Motions of the other Planets, produce extravagant Appearances.	296	The Earths Annual Motion thorow the Ecliptick unequal, by reason of the Moons Motion.	413
Rest, Annual Motion, and the Diurnal, ought to be distributed betwixt the Sun, Earth, and Firmament.	300	The Causes of the inequality of the Additions and Substractions of the Diurnal Conversion from the Annual Motion.	418
Granting to the Earth the Annual, it must of necessity have the Diurnal Motion assigned to it.	300	CIRCULAR MOTION: Circular and Right Motion are simple, as proceeding in simple Lines.	6
The sole Annual Motion of the Earth, causeth great inequality in the Motions of the Planets.	310	The Circular Motion is never acquired Naturally, unless Right Motion precede it.	18
A Demonstration of the inequalities of the three superiour Planets dependent on the Annual Motion of the Earth.	310	Circular Motion perpetually uniforme.	18
The Annual Motion of the Earth most apt to render a reason of the Exorbitance of the five Planets.	312	In the Circular Motion every point in the Circumference is the beginning and end.	20
Argument of Tycho against the Annual Motion, from the invariable Elevation of the Pole.	338	Circular Motion onely is Uniforme.	20
Upon the Annual Motion of the Earth, alteration may ensue in some Fixed Stars, not in the Pole.	341	Circular Motion may be continued perpetually.	20
The Paralogisme of those who believe that in the Annual Motion great alterations are to be made about the Elevation of the Fixed Stars, is confuted.	341	Circular Motion onely and Rest are apt to conserve Order.	20
Enquiry is made what mutations, and in what Stars, are to be discovered by means of the Earths Annual Motion.	342	To the Circular Motion no other Motion is contrary.	26
Astronomers having omitted to instance what alterations those are that may be derived from the Annual Motion of the Earth, do thereby testifie that they never rightly understood the same.	343	Circular Motions are not contrary, according to Aristotle.	100
The Annual Motion made by the Centre of the Earth under the Ecliptick, and the Diurnal Motion made by the Earth about its own Centre.	344	The Motion of the Parts of the Earth returning to their Whole, may be Circular.	237
Objections against the Earths Annual Motion taken from the Fixed Stars placed in the Ecliptick.		The Velocity in the Circular Motion encreaseth according to the encrease of the Diameter of the Circle.	242
		Circular Motion is truly simple and perpetual.	495
		Circular Motion belongeth to the Whole Body, and the Right to its Parts.	496
		Circular and Right Motion are coincident, and may consist together in the same Body.	496
		COMMON MOTION: A notable Instance of Sagredus, to shew the non-operating of Common Motion.	151
		An Experiment that sheweth how the Common Motion is imperceptible.	224
		The concurrence of the Elements in a Common Motion imports no more than their concurrence in a Common Rest.	239
		Common Motion is as if it never were.	223, 240
		COMPRESSIVE MOTION: Compressive Motion is proper to Gravity, Extensive to Levity.	497
		CON.	

X X X

The Table.

CONTRARY MOTIONS: An Experiment which plainly shews that two Contrary Motions may agree in the same Moveable. 363

The parts of a Circle regularly moved about its own Centre, move in diverse times with Contrary Motions. 389

DESCENDING MOTION: The Inclination of Grave Bodies to the Motion of Descent, is equal to their resistance to the Motion of Ascent. 191

The Spaces past in the Descending Motion of the falling Grave Body, are as the Squares of their times. 198

The Motion of Descent belongs not to the Terrestrial Globe, but to its parts. 362

DIURNAL MOTION: The Diurnal Motion seemeth Common to all the Universe, the Earth only excepted. 97

Diurnal Motion: why it should more probably belong to the Earth than to the Rest of the Universe. 98

The first Discourse to prove that the Diurnal Motion belongs to the Earth. 99

The Diurnal Motion causeth no Mutation among Celestial Bodies, but all changes have relation to the Earth. 100

A second Confirmation that the Diurnal Motion belongs to the Earth. 100

A third Confirmation that the Diurnal Motion belongs to the Earth. 101

A fourth, fifth, and sixth Confirmation that the Diurnal Motion belongs to the Earth. 102

A seventh Confirmation that the Diurnal Motion belongs to the Earth. 103

If the Diurnal Motion should alter, the Annual Period would cease. 409

LOCAL MOTION: Local Motion of three kinds, Right, Circular, and Mixt. 6

An entire and new Science of our Academick [Galileo] concerning Local Motion. 198

MIXT MOTION: Of Mixt Motion we see not the part that is Circular, because we partake thereof. 218

Aristotle granteth a Mixt Motion to Mixt Bodies. 375

The Motion of Mixt Bodies ought to be such as may result from the Composition of the Motions of the simple Bodies compounding. 375

NATURAL MOTION: Acceleration of the Natural Motion of Graves is made according to the Odd Numbers beginning at Unity. 198

Natural Motion changeth into that which is Preter-Natural and Violent. 212

PROGRESSIVE MOTION: The Progressive Mo-

Motion may make the Water in a Vessel to run to and fro. 387

RIGHT MOTION: Sometimes Simple, and sometimes Mixt, according to Aristotle. 8

Right Motion impossible in the World exactly Ordinate. 10

Right Motion Naturally Infinite. 10

Right Motion Naturally Impossible. 10

Right Motion might possibly have been in the First Chaos. 11

Right Motion is useful to reduce into Order things out of Order. 11

Right Motion cannot naturally be Perpetual. 20

Right Motion assigned to Natural Bodies, to reduce them to perfect Order, when removed from their Places. 20

Right Motion of Grave Bodies manifest to Sense. 22

Right Motion with more reason ascribed to the Parts, than to the whole Elements. 33

Right Motion cannot be Eternal, and consequently cannot be Natural to the Earth. 117

Right Motion seemeth to be wholly excluded in Nature. 147

With two Right Motions one cannot compose Circular Motions. 375

Right Motion belongeth to imperfect Bodies, and that are out of their Natural Places. 495

Right Motion is not Simple. 495

Right Motion is ever mixt with the Circular. 495

SIMPLE MOTION peculiar onely to Simple Bodies. 494

TERRESTRIAL MOTION collected from the Stars. 229

The Parts of the Terrestrial Globe accelerate and retard in their Motion. 388

One single Terrestrial Motion sufficeth not to produce the Ebbing and Flowing. 421

UNEVEN MOTION may make the Water in a Vessel to Run to and fro. 387

The Mixture of the two Motions Annual and Diurnal, causeth the unevenness in the Motion of the parts of the Terrestrial Globe. 350

MOVE.

Its questionable whether descending Bodies Move in a Right Line. 21

Aristotles Argument to prove that Grave Bodies Move with an inclination to arrive at the Centre. 22

Grave Bodies Move towards the Centre of the Centre of the Earth per Accidens. 22

Things forsaking the place which was natural ro them by Creation, are said to Move violently, and

The Table

and naturally tend to return back to the same. 492

MOVEABLE, &c.

A *Moveable* being in the state of Rest shall not move unlesse it have an inclination to some particular Place. 11

The *Moveable* accelerates its Motion in going towards the Place whither it hath an inclination. 11

The *Moveable* departing from Rest goeth thorow all the Degrees of Tardity. 11

The *Moveable* doth not accelerate save only as it approacheth near to its terme of Rest. 12

To introduce in a *Moveable* a certain Degree of Velocity, Nature made it to move in a Right Line. 12

The *Moveable* departing from Rest passeth through all the Degrees of Velocity without staying in any. 13

The *Grave Moveable* descending, acquireth Impetus sufficient to re-carry it to the like height. 13

The Impetus of *Moveables* equally approaching to the Centre are equal. 14

Upon an Horizontal Plane the *Moveable* lyeth still. 14

A single *Moveable* hath but one only Natural Motion, and all the rest are by participation. 103

A Line described by a *Moveable* in its Natural Descent, the Motion of the Earth about its own Centre being presupposed, would probably be the Circumference of a Circle. 145

A *Moveable* falling from the top of a Tower moveth in the Circumference of a Circle. 146

A *Moveable* falling from a Tower moveth neither more nor lesse, then if it had staid alwayes there. 146

A *Moveable* falling from a Tower moveth with an Uniforme not an Accelerate Motion. 146

The *Cadent Moveable*, if it fall with a Degree of Velocity acquired in a like time with an Uniform Motion, it shall passe a space double to that passed with the Accelerate Motion. 202

Admirable Problems of *Moveables* descending by the Quadrant of a Circle, and those descending by all the Chords of the whole Circle. 412

MUNDANE.

Mundane Bodies were moved in the beginning in a Right Line, and afterwards circularly, according to *Plato*. 11

N A-

N

NATURAL.

That which is Violent cannot be Eternall, and that which is Eternal cannot be *Natural*. 116

NATURE, and Natures.

Nature attempts not things impossible to be effected. 10

Nature never doth that by many things which may be done by a few. 99

Nature first made things as she pleased, and afterwards capacitated Mans understanding for conceiving of them. 238

From Common Accidents one cannot know different *Natures*. 238

Natures Order is to make the lesser Orbes to Circulate in shorter times; and the bigger in longer. 243

That which to us is hard to be understood, is with *Nature* easie to be effected. 403

Nature keeping within the bounds assigned her, little careth that her Methods of operating fall within the reach of Humane Capacity. 433

Natures Actions no less admirably discover God to us than Scripture Dictions. 434

NERVES.

The Original of the *Nervus* according to Aristotle, and according to Physicians. 91

The ridiculous Answer of a Philosopher determining the Original of the *Nerves*. 91

O

OBJECTS.

Objects, the more Vigorous they are in Light, the more they do seem to encrease. 305

That Remote *Objects* appear so small is the Defect of the Eye, as is demonstrated. 337

In *Objects* far Remote and Luminous, a small accession or recession is imperceptible. 356

OPINIONS.

It's all one, whether *Opinions* are new to Men, or Men new to *Opinions*. 77

ORBE, and Orbes.

The greater *Orbes* make their Conversions in greater

The Table.

greater times. 101 331
It's more rational, that the *Orbe* containing and
the Parts contained do move all about one
Centre, than about divers. 255

P

PASSIONS.

Infinite *Passions* are perhaps but one onely. 87

PENDULUM, and Pendula.

Pendula might have a perpetual Motion, impedi-
ments being removed. 203
The *Pendulum* hanging at a longer thread maketh
its Vibrations more seldome than the *Pendu-*
lum hanging at a shorter. 206
The Vibrations of the same *Pendulum* are made
with the same frequency, whether they be
small or great. 206
The cause which impedeth the *Pendulum*, and
reduceth it to rest. 206
The thread or Chain to which the *Pendulum* is
fastened maketh an Arch, and doth not stretch
it self straight out in its Vibrations. 207
Two particular notable Accidents in the *Pendula*
and their Vibrations. 411

PERIPATETICK, &c.

Peripatetick Philosophy unchangeable. 42
A brave resolution of a certain *Peripatetick*
Philosopher to prove the Right Line to be the
shortest of all Lines. 182
The Paralogisme of the said *Peripatetick* who
proveth *Ignotum per ignotum*. 183
The Discourses of *Peripateticks* full of Errors and
Contradictions. 376
The *Peripateticks* persecuted Galileo out of envy
to his happy Discoveries in Philosophy. 427
The *Peripateticks* in defect of Reasons repair to
Scripture for Arguments against their
Adversaries. 429

PHYLOSOPHERS.

It is not just, that those who never *Phylosophate*,
should usurp the title of *Phylosophers*. 96

PHYLOSOPHY.

The Disputes and Contradictions of *Phylosophers*
may conduce to the benefit of *Phylosophy*. 25
A cunning way to gather *Phylosophy* out of any
Book whatsoever. 92

PLA-

PLANETS.

The approximation and recession of the three
superiour *Planets* importeth double the Suns
distance. 299
The difference of the *Planets* apparent Magni-
tude lesse in Saturn than in Jupiter, and lesse
in Jupiter than in Mars, and why. 299
The Station, Direction, and Retrogradation of
the *Planets* is known in relation to the fixed
Stars. 347
The particular Structures of the Orbes of the
Planets not yet well resolved. 416
The *Planets* places may more certainly be
assigned by this Doctrine, than by that of
Ptolomies great Almagest. 469

PLATO.

Plato held, that Humane understanding pertook
of Divinity, because it understood Num-
bers. 3
Plato his *Ænigma*, and the Interpretation of
it. 498

POLE.

The invariable Elevation of the *Pole* urged as an
Argument against the Annual Motion. 338
An Example to prove that the Altitude of the
Pole ought not to vary by means of the Earths
Annual Motion. 340

POWER.

Of an infinite *Power* one would think a greater
part should rather be employed than a
lesser. 105

PRINCIPLES.

By denying *Principles* in Sciences, any Paradox
may be maintained. 28
Contrary *Principles* cannot naturally reside in
the same Subject. 211

PROJECT, &c.

The *Project*, according to Aristotle, is not mo-
ved by virtue impressed, but by the Me-
dium. 130
Operation of the Medium in continuing the
Motion of the *Project*. 131
Many Experiments and Reasons against the
Motions of *Project*s assigned by Aristotle. 132
The Medium doth impede and not conferre the
Mo-

The Table.

Motion of *Projectz*. 134
 An admirable accident in the Motion of *Projectz*. 135
 Sundry curious Problems touching the Motion of *Projectz*. 137
Projectz continue their Motion by a Right Line that follows the direction of the Motion made together with the *Projicient*, whilst they were conjoynd therewith. 154
 The Motion impressed by the *Projicient* is onely in a Right Line. 170
 The *Projectz* moveth by the Tangent of the Circle of the Motion preceeding in the instant of Seperation. 172
 A Grave *Projectz* as soon as it is seperated from the *Projicient*, beginneth to decline. 173
 The Cause of the *Projection* encreaseeth not according to the Proportion of Velocity encreased by making the Wheel bigger. 189
 The Virtue which carrieth Grave *Projectz* upwards, is no lesse Natural to them than the Gravity which moveth them downwards. 211

P T O L O M Y, &c.

Inconveniences that are in the System of *Ptolomy*. 309
Ptolomies System full of defects. 476
 The Learned both of elder and later times dissatisfied with the *Ptolomaick* System. 477

P Y T H A G O R A S, &c.

Pythagorick Mystery of Numbers fabulous. 3
Pythagoras offered an Hecatomb for a Geometrical Demonstration which he found. 38
Pythagoras and many other Ancients enumerated, that held the Earths Mobility. 437 & 468

R

R A Y S.

Shining Objects seem fringed and environed with adventitious Rays. 304

R I S T.

Ref. Vide Motion.
 Ref. the Infinite degree of Tardity. 11

R E T R O G R A D A T I O N S.

Retrogradations more frequent in Saturn, lesse frequent in Jupiter, and yet lesse in Mars, and

and why. 311
 The *Retrogradations* of Venus and Mercury demonstrated by Apollonius and Copernicus. 311

S

S A T U R N.

Saturn for its slownesse, and Mercury for its late appearing, were amongst those that were last observed. 416

S C A R C I T Y.

Scarcity and Plenty enhance and debase the price of all things. 43

S C H E I N E R.

Christopher *Scheiner* the Jesuit his Book of Conclusions confuted. 78 & 195, & seq. & 323
 A Canon Buller would spend more than six dayes in falling from the Concave of the Moon to the Center of the Earth, according to *Scheiner*. 195
 Christopher *Scheiner* his Book entituled *Apelles post Tabulam* censured, and disproved. 313
 The Objections of *Scheiner* by way of Interrogation. 336
 Answers to the Interrogations of *Scheiner*. 336
 Questions put to *Scheiner*, by which the weakness of his is made appear. 336

S C I E N C E S.

In Natural Sciences the Art of Oratory is of no use. 40
 In Natural Sciences it is not necessary to seek Mathematical evidence. 206

S C R I P T U R E, &c.

The Caution we are to use in determining the Sense of *Scripture* in difficult points of Philosophy. 427
Scripture studiously condescendeth to the apprehension of the Vulgar. 432
 In discussing of Natural Questions, we ought not to begin at *Scripture*, but at Sensible Experiments and Necessary Demonstrations. 433
 The intent of *Scripture* is by its Authority to recommend those Truths to our belief, which being un-intelligible, could no other wayes be rendered credible. 434

Y y y

Strip-

The Table.

Scripture Authority to be preferred, even in Natural Controversies to such Sciences as are not confined to a Demonstrative Method. 434

The Pen-men of *Scripture*, though read in Astronomy, intentionally forbear to teach us any thing of the Nature of the Stars. 435

The Spirit had no intent at the Writing of the *Scripture*, to teach us whether the Earth moveth or standeth still, as nothing concerning our Salvation. 436

Inconveniencies that arise from licentious usurping of *Scripture*, to stuffe out Books that treat of Nat. Arguments. 438

The Literal Sense of *Scripture* joyned with the universal consent of the Fathers, is to be received without farther dispute. 444

A Text of *Scripture* ought no lesse diligently to be reconciled with a Demonstrated Proposition in Philosophy, than with another Text of *Scripture* sounding to a contrary Sense. 446

Demonstrated Truth ought to assist the Commentator in finding the true Sense of *Scripture*. 446

It was necessary by way of condescension to Vulgar Capacities, that the *Scripture* should speak of the Rest and Motion of the Sun and Earth in the same manner that it doth. 447

Not onely the Incapacity of the Vulgar, but the Current Opinion of those times, made the Sacred Writers of the *Scripture* to accommodate themselves to Popular Esteem more than Truth. 447

The *Scripture* had much more reason to affirm the Sun Moveable, and the Earth Immoveable, than otherwise. 448

Circumspection of the Fathers about imposing positive Senses on Doubtful Texts of *Scripture*. 451

Tis Cowardice makes the Anti-Copernican fly to *Scripture* Authorities, thinking thereby to affright their Adversaries. 455

Scripture speaks in Vulgar and Common Points after the manner of Men. 462

The intent of *Scripture* is to be observed in Places that seem to affirme the Earths Stability. 464

Scripture Authorities that seem to affirm the Motion of the Sun and Stability of the Earth, divided into six Classes. 478

Six Maxims to be observed in Expounding Dark Texts of *Scripture*. 481

Scripture Texts speaking of things inconvenient to be understood in their Literal Sense, are to be interpreted one of the four wayes named.

named. 81

Why the Sacred *Scripture* accommodates it self to the Sense of the Vulgar. 487

S E A.

The *Seas* Surface would shew at a distance more obscure than the Land. 49

The *Seas* Reflection of Light much weaker than that of the Earth. 81

The Isles are tokens of the unevenness of the Bottoms of *Seas*. 383

S E L E U C U S.

Opinion of *Seleucus* the Mathematician confessed. 422

S E N S E.

He who denieth *Sense*, deserves to be deprived of it. 21

Sense sheweth that things Grave move ad Medium, and the Light to the Concave. 21

It is not probable that God who gave us our Senses, would have us lay them aside, and look for other Proofs for such Natural Points as *Sense* sets before our Eyes. 434

Sense and Reason lesse certain than Faith. 475

S I L V E R.

Silver burnished appears much more obscure than the unburnished, and why. 64

S I M P L I C I U S.

Simplicius his Declamation. 43

S O C R A T E S.

The Answer of the Oracle true in judging *Socrates* the Wifest of his time. 85

S O R I T E S.

The Forked Sylogisme called *Sorites*. 29

S P E A K I N G.

We cannot abstract our manner of *Speaking* from our Sense of Seeing. 461

S P H E R E.

The Motion of 24 hours ascribed to the Highest *Sphere*.

The Table.

Sphere, disorders the Period of the Inferi-
our. 102
The *Sphere* although Material, toucheth the
Material Plane but in one point onely. 182
The Definition of the *Sphere*. 182
A Demonstration that the *Sphere* toucheth the
Plane but in one point. 183
Why the *Sphere* in abstract toucheth the Plane
onely in one point, and not the Material in
Concrete. 184
Contract in a Single Point is not peculiar to the
perfect *Sphere* onely, but belongeth to all
Curved Figures. 185
In a Moveable *Sphere* it seemeth more reasona-
ble that its Centre be stable, than any of its
parts. 300

SPHERE of Activity.

The *Sphere* of Activity greater in Celestial Bo-
dies than in Elementary. 59

STARRY SPHERE.

Wearinesse more to be feared in the *Starry Sphere*
than in the Terrestrial Globe. 245
By the proportion of Jupiter and of Mars, the
Starry Sphere is found to be yet more re-
mote. 331
Vanity of those mens discourse, who argue
the *Starry Sphere* to be too vast in the Coper-
nican Hypothesis. 335
The whole *Starry Sphere* beheld from a great di-
stance, might appear as small as one single
Star. 335

SPHERICAL.

The Spherical Figure is easier to be made than
any other. 186
Spherical Figures of sundry Magnitudes, may
be made with one sole Instrument. 187

SPIRIT.

The *Spirit* had no intent to teach us whether
the Earth moveth or standeth still, as no-
thing concerning our Salvation. 436

SOLAR SPOTS.

Spots generate and dissolve in the face of the
Sun. 38
Sundry Opinions touching the *Solar Spots*. 39
An Argument that necessarily proveth the *So-*
lar Spots to generate and dissolve. 40
A

A conclusive Demonstration to prove that the
Spots are contiguous to the Body of the
Sun. 41

The Motion of the *Spots* towards the Circum-
ference of the Sun appears slow. 41

The Figure of the *Spots* towards the Circumfe-
rence of the Suns Discus, appear narrow,
and why. 41

The *Solar Spots* are not Spherical, but flat, like
thin plates. 41

The History of the proceedings of the Acade-
mian for a long time about the Observation
of the *Solar Spots*. 312

A conceit that suddenly came into the mind of
our Academician concerning the great conse-
quence that followeth upon the Motion of
the *Solar Spots*. 314

Extravagant Mutations to be observed in the
Motions of the *Solar Spots* foreseen by the
Academick, in case the Earth had the Annu-
al Motion. 314

The first Accident to be observed in the Moti-
on of the *Solar Spots*, and consequently all
the rest, explained. 315

The events being observed were answerable to
the Predictions touching these *Spots*. 318

Though the Annual Motion assigned to the
Earth, answereth to the Phenomena of the
Solar Spots, yet doth it not follow by conver-
sion, that from the Phenomena of the *Spots*
one may inferre the Annual Motion to be-
long to the Earth. 319

The Pure Peripatetick Philosophers will laugh
at the *Spots* and their Phenomena, as the
Illusions of the Christsals in the Tele-
scope. 319

The *Solar Spots* of Galileo. 494

STAR and Stars.

The Stars infinitely surpass the rest of Heaven
in Density. 30

It is no lesse impossible for a Star to corrupt,
than the whole Terrestrial Globe. 37

New Stars discovered in Heaven. 38

The small Body of a Star fringed about with
Rays, appeareth very much bigger than
plain, naked, and in its native Clarity. 61

An easie Experiment that sheweth the encrease
in the Stars, by means of the Adventitious
Rays. 305

A Star of the Sixth Magnitude supposed by Ty-
cho and Scheiner an hundred and six Millions
of times bigger than needs. 326

A common error of all Astronomers touching
the Magnitude of the Stars. 326
Venus

The Table.

Venus rendereth the Errour of Astronomers
in determining the Magnitudes of Stars in-
excusable. 326
A way to measure the the apparent Diameter
of a Star. 327
By depriving Heaven of some Star, one might
come to know what influence it hath upon
us. 334
Enquiry is made what Mutations, and in what
Stars, is to be made by means of the Annual
Motion of the Earth. 342
The Stars neerer to us make greater diversities
than the more remote. 349

FIXED STARS.

Great disparity amongst the Motions of the
Particular *Fixed Stars* if their Sphere be
moveable. 102
The Motions of the *Fixed Stars* would accele-
rate and retard in several times, if the Starry
were moveable. 102
The Probable Situation of the *Fixed Stars*. 299
Supposing the Annual Motion of the Earth, it
followeth that one *Fixed Star* is bigger than
the whole Grand Orbe. 324
The apparent diversity of Motion in the Pla-
nets, is insensible in the *Fixed Stars*. 325
Supposing that a *Fixed Star* of the First Magni-
tude is no bigger than the Sun, the diversity
which is to great in the Planets, is al-
most insensible in the *Fixed Stars*. 325
The Diameter of a *Fixed Star* of the First Mag-
nitude, and one of the Sixth. 325
The distance of a *Fixed Star* of the First Magni-
tude, the Star being supposed to be equal to
the Sun. 326
In the *Fixed Stars* the diversity of Aspect caused
by the Grand Orb, is little more than that
caused by the Earth in the Sun. 326
The Computation of the Magnitude of the
Fixed Stars in respect of the Grand
Orbe. 326
The Apparent Diameter of a *Fixed Star* of the
First Magnitude, not more than five Se-
conds. 328
By another Supposition taken from Astrono-
mers, the distance of the *Fixed Stars* is cal-
culated to be 10800 Semidiameters of the
Great Orbe. 331
The place assigned to a *Fixed Star* is much lesse
than that of Planet. 335
The Mutations of the *Fixed Stars* ought to be
in some greater, in others lesser, and in o-
thers nothing at all. 343
The grand Difficulty in Copernicus his Do-
ctrine

is, is that which concerns the Pheno-
mena of the Sun and *Fixed Stars*. 343
The *Fixed Stars* in the Ecliptick never Elevate
nor Descend, on account of the Annual
Motion, but yet approach and recede. 345
The *Fixed Stars* without the Ecliptick elevate
more or lesse, according to their distance
from the Ecliptick. 347
The Epilogue to the Phenomena of the *Fixed
Stars* caused by the Annual Motion of the
Earth. 349
A place accommodated for the Observation of
the *Fixed Stars*, as to what concerns the An-
nual Motion of the Earth. 352

NEW STAR.

The greatest and least Elevation of the *New
Star* differ not from each other more than the
Polar Altitudes, the said Star being in the
Firmament. 255

STEEL.

Steel Burnished, beheld from one place appears
very bright, and from another, very ob-
scure. 64

STONE.

The Stone falling from the Mast of a Ship lights
in the same place, whether the Ship move
or stands still. 125

STRENGTH.

The Strength diminisheth nor, were it not em-
ployed. 244

SUN.

The Sun more probably in the Centre of the
Universe than the Earth. 21
Observations from whence it is collected that
the Sun and not the Earth, is in the Centre
of the Celestial Revolutions. 295
The Sun and Moon encrease little by Irradia-
tion. 305
The Sun it self resisteth the Annual Motion to
belong to the Earth. 312
If the Earth be immoveable in the Centre of
the Zodiack, there must be ascribed to the
Sun four several Motions, as is declared at
length. 320
The distance of the Sun conteineeth twelve
hundred and eight Semidiameters of the
Earth.

The Table.

Earth.	325
The Diameter of the <i>Sun</i> half a Degree.	325
The Apparent Diameter of the <i>Sun</i> how much it is bigger than that of a Fixed Star.	325
An Example of Gods care of Mankind, taken from the <i>Sun</i> .	333
An exquisite Observation of the approach and departure of the <i>Sun</i> from the Summer Solstice.	352
The <i>Sun</i> passeth one half of the Zodiack nine dayes sooner than the other.	416
The Miracle in Joshua of the <i>Suns</i> standing still answers not to the intent of lengthening the day, but on the contrary excellently agreeth with the Copernican Systeme.	456
The <i>Sun</i> without change of place revolveth upon its own Centre in the space of a Moneth.	457
The Nobility of the <i>Sun</i> as being the Fountain of Light, Heart of the World, and Principle of Motion.	457
The <i>Suns</i> standing still in Joshua explained by Kepler.	462
The <i>Sun</i> found to be neerer to us than in times past, by five thousand Miles.	469
The <i>Sun</i> , Moon, and Stars, are one and the same thing.	485
Why the <i>Sun</i> to our thinking moveth, and not the Earth.	486
How the <i>Sun</i> is said to rise and set by extrinsick denomination.	489
The <i>Sun</i> is the King, Heart, and Lamp of the World.	497

SYMPATHY.

<i>Sympathy</i> and Antipathy, terms introduced by Phylosophers, the more easily to give a reason of many Natural Effects.	373
--	-----

SYSTEM of Copernicus.

The <i>Copernican System</i> once admitted for true, Expositions might be found out for all those Scriptures than that seem to make against it.	459
Didacus a Stunica held that the Scripture may be best expounded by the <i>Copernican System</i> .	468

SYSTEM of Universe.

The <i>System of the Universe</i> designed from the Appearances.	296
The <i>System of the Universe</i> might probably have been intended to have been represented by the	

the Golden Candlestick.	500
The <i>System</i> represented likewise by the Apple in Paradice.	501

T

TELESCOPE.

The <i>Telescope</i> enableeth us to discourse better of Celestial Matters than Aristotle himself.	42
Invention of the <i>Telescope</i> taken from Aristotle.	92
An ingenious Consideration about using of the <i>Telescope</i> with as much facility on the Round-top of the Mast of a Ship, as on the Deck.	225
The Mutations made in the <i>Telescope</i> , depending on the Agitation of the Ship.	226
The Operations of the <i>Telescope</i> accounted Fallacies by the Peripateticks.	304 & 319
The <i>Telescope</i> is the best means to take away the Irradiations of the Stars.	306
The <i>Telescope</i> hath much contributed to the Restauration of Astronomy.	476

THEOLOGY.

<i>Theology</i> the Queen of the Sciences, and wherein her Prerogative consists.	44
--	----

THINGS.

Some <i>Things</i> are of that nature, that their parts may separate from one another, and from their whole, others not.	492
<i>Things</i> are simply denominated in comparison of all or the greatest number of things of that kinde.	496

THREE.

The Number <i>Three</i> celebrated amongst the Pythagoreans.	2
--	---

TIDE.

The <i>Tide</i> and the Mobility of the Earth mutually confirm each other.	386
<i>Tide</i> . Vide <i>Ebbing</i> and <i>Flowing</i> .	

TRUE.

<i>True</i> and <i>Fair</i> are one and the same, as also <i>False</i> and <i>Deformed</i> .	115
For proof of <i>True</i> Conclusions, many solid Arguments may be produced, but to prove	
Z z z	2

The Table.

a false one, none.

112. 245

TRUTH, and Truths.

Untruths cannot be Demonstrated as Truths are.

112

The Truth sometimes gains strength by Contradiction.

181

Truth hath not so little light as not to be discovered amongst the Umbrages of Fashions.

384

TYCHO.

The Argument of Tycho grounded upon a false Hypothesis.

374

Tycho and his Followers never attempted to see whether there were any Phenomena in the Firmament for or against the Annual Motion.

337

Tycho and others argue against the Annual Motion, from the invariable Elevation of the Pole.

338

V

VELOCITY.

Uniform Velocity suitable with Circular Motion.

12

Nature doth not immediately conferre a determinate degree of Velocity, although She could.

12

The Velocity by the inclining plane equal to the Velocity by the Perpendicular, and the Motion by the Perpendicular swifter than by the inclining plane.

14

Velocities are said to be equal, when the Spaces passed are proportionate to their times.

15

The greater Velocity exactly compensates the greater Gravity.

192

VENUS.

The Mutation of Figure in Venus argueth its Motion to be about the Sun.

295

Venus very great towards the Vespertine Conjunction, and very small towards the Matutine.

297

Venus necessarily proved to move about the Sun.

298

The Phenomena of Venus appear contrary to the System of Copernicus.

302

Another Difficulty raised by Venus against Copernicus.

302

Venus according to Copernicus either lucid in itself, or a transparent substance.

302

The Reason why Venus and Mars do not appear to vary Magnitude so much as is requisite.

303

A second Reason of the small apparent encrease of Venus.

306

Venus renders the Errour of Astronomers in determining the Magnitude of Stars inexcusable.

327

VESSEL.

Of the Motion of Water in a Vessel. Vide Water.

UNDERSTAND, &c.

Man Understandeth very much intensely, but little extensively.

86

Humane Understanding operates by Ratiocination.

87

UNIVERSE.

The Constitution of the Universe is one of the Noblest Problems a Man can study.

127

The Centre of the Universe according to Aristotle is that Point about which the Celestial Spheres do revolve.

294

Which ought to be accounted the Sphere of the Universe.

299

It is a great rashness to censure that to be superfluous in the Universe which we do not perceive to be made for us.

334

VURSTITIUS.

Christianus Vurstittus read certain Lectures touching the Opinion of Copernicus, and what happened thereupon.

110

W

WATER.

He that had not heard of the Element of Water, could never fancie to himself Ships and Fishes.

47

An Experiment to prove the Reflection of Water less bright than that of the Land.

81

The Motion of the Water in Ebbing and Flowing, not interrupted by Rest.

251

The vain Argumentation of some, to prove the Element of Water to be of a Spherical Superficies.

377

The

The Table.

The Progressive and uneven Motion makes the
Water in a Vessel to run to and fro. 387
 The Several Motions in the continuing Vessel,
 may make the contained *water* to rise and
 fall. 387
 The *Water* raised in one end of the Vessel re-
 turneth it self to *Equilibrium*. 391
 In the shorter Vessels the Undulations of *Wa-*
ters are more frequent. 391
 The greater profundity maketh the Undulati-
 ons of *Water* the more frequent. 391
 Why in narrow places the Course of the *Wa-*
ters is swifter than in larger. 396
 The cause why in some narrow Channells, we
 see the Sea-*Waters* run alwayes one way. 398
 The *Water* more apt to conserve an Impetus
 conceived than the Air. 400
 The Motion of the *Water* dependeth on the
 Motion of Heaven. 404

WEIGHTS.

Its questionable whether Descending *Weights*
 move in a Right Line. 21

WEST.

The Course to the *West* India's easie, the re-
 turn difficult. 402

WINDE.

Constant Gales of *Winde* within the Tropicks
 blow towards the West. 402
Winds from the Land, make rough the
 Seas. 402

WISDOME Divine.

Divine Wisdome infinitely infinite. 85
 The Discourses which Humane Reason makes

in time, the *Divine wisdom* resolveth in a
 Moment, that is hath them alwayes pre-
 sent. 87

WIT.

The *Wit* of Man admirably acute. 87
 The Puslanimity of Popular *Wits*. 364
 Poetick *Wits* of two kinds. 384

WORLD.

World. Vide Universe.

The *Worlds* parts are according to Aristotle two,
 Celestial and Elementary, contrary to each
 other. 6
 The *World* supposed by the Anthour [Galileo]
 to be perfectly Ordinate. 10
 The Sensible *World*. 96
 It hath not been hitherto proved by any whe-
 ther the *World* be finite or infinite. 293
 If the Centre of the *World* be the same with
 that about which the Planets move, the Sun
 and not the Earth is placed in it. 295

WRITING.

Some *Write* what they understand not, and
 therefore understand not what they *Write*. 63
 The Invention of *Writing* Stupendious above
 all others. 88

Y

YEAR.

The *Years* beginning and ending, which Ptolomy
 and his Followers could never positively as-
 sign, is exactly determined by the Coper-
 nican Hypothesis. 469

THE END OF THE TABLE.

MATHEMATICAL
COLLECTIONS
AND
TRANSLATIONS:
THE SECOND
TOME.

THE SECOND PART;

Containing,

- I. D. BENEDICTUS CASTELLUS, *his* DISCOURSE
of the *MENSURATION* of *RUN-*
NING WATERS.
 - II. *His* Geometrical DEMONSTRATIONS of
the Measure of *RUNNING WATERS*.
 - III. *His* LETTERS and CONSIDERATIONS
touching the Draining of *FENNS*, *Diversions* of
RIVERS, &c.
 - IV. D. CORSINUS, *His* RELATION of the state of the
Inundations, &c. in the Territories of *BOLOGNA*,
and *FERRARA*.
-

- By THOMAS SALUSBURY, Esq.

LONDON,
Printed by WILLIAM LEYBOURNE, MDCLXI.

A a a a

MATRICES
COLLECTIONS

AND

TRANSLATIONS

THE SECOND

VOLUME

THE SECOND PART

Containing

The History of the Christian Church

from the Birth of Christ to the

Present Time

By the Rev. John G. ...

of the University of ...

London

Printed by ...

in the Strand

1801

BY ...

LONDON

Printed by William ...

1801

OF THE
MENSURATION
OF
RUNNING WATERS.

An Excellent Piece

Written in ITALIAN

BY

DON BENEDETTO CASTELLI,
Abbot of St. *BENEDETTO ALOYSIO*,
and Professour of the Mathematicks to
Pope *URBAN VIII.* in *ROME.*

Englised from the Third and best Edition, with
the addition of a Second Book not before extant:

By *THOMAS SALUSBURY.*

L O N D O N,
Printed by WILLIAM LEYBOURN, 1661.

A a a a 2

OF THE
MEASUREMENT
OF
RUNNING WATERS.

BY
DANIEL WATTS

OF THE
ART OF THE
ART OF THE
ART OF THE

OF THE
OF THE
OF THE

OF THE
OF THE
OF THE

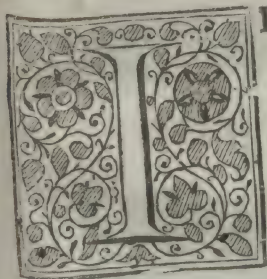
OF THE
OF THE
OF THE

OF THE
OF THE
OF THE

OF THE
OF THE
OF THE



THE
AUTHOURS EPISTLE
TO
Pope VRBAN VIII.



Lay at the Feet of your Ho-
lineffe these my Conside-
rations concerning the
MENSURATION OF
RUNNING WATERS:

Wherein if I shall have succeeded, being a
matter so difficult and unhandled by Wri-
ters both Ancient Modern, the discovery of
any thing of truth hath been the Effect of
Your Holinesses Command; and if through
inability I have missed the Mark, the same

¶

Com-

Command will serve me for an Excuse with
Men of better Judgment, and more especi-
ally with Your Holinesse, to whom I humbly
prostrate my self, and kisse Your Sacred
Feet.

From ROME.

Your Holinesses

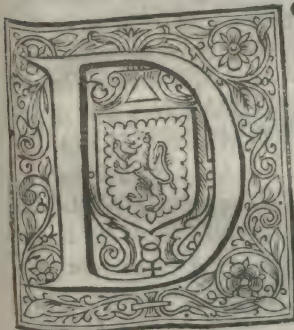
Most humble Servant

BENEDETTO.

A Monk of Cassino.



A N
A C C O U N T
O F T H E
Authour and Work.



ON BENEDETTO CASTELLI,
the famous Authour of these ensuing
Discourses of the Menluration of
Running Waters, is descended from
the Worshipful FAMILY of the
CASTELLII, and took his
first breath near to the lake THRAS-
SIMENVS, (where Hanibal gave
a fatal overthrow to the Roman
Legions) in that sweet and fertile part
of happy ITALY, called the Territory
of PERUGIA, a branch of the Dukedome of TUSCANY, which
at present submitteih to the Jurisdiction of the Church, as being a
Part of St. PETER'S Patrimony. His Parents, who were more
zealous of the good of his Soul than observant of the Propension of
his Genius, dedicated him (according to the Devotion of that Coun-
try) to the Service of the Church; and entered him into the Flou-
rishing Order of Black-Friers, called from the place Monchs
of Monte Calino, and from the Founder Benedicines. Na-
ture, that She might consummate the Profusion of her Fa-
vours upon him, sent him into the World in an Age that was so
ennobled and illuminated with Eminent Scholars in all Kinds of
Literature, that hardly any Century since the Creation can boast
the like.

AN ACCOUNT OF

§. In particular, the SCIENCES MATHEMATICAL had then got that Fame and Esteem in the Learned World, that all men of Spirit or Quality became either Students in, or Patrons of those Sublime Knowledges. On this occasion the Curiosity of our AUTHOUR being awakened, his Active Wit could not endure to be any longer confined to the Slavish Tuition of Hermetical Pedagogues; but in concurrence with the Genius of the Age, he also betook himself to those most Generous and Liberal Studies. His helps in this his design were so many, and so extraordinary, that had his Inclination been weaker, or his Apprehension lesser, he could hardly have failed attaining more than a Common Eminency in these Sciences. For besides the Deluge of Learned and Useful Books, which the Presse at that time sent forth from all parts of EUROPE, he had the good Fortune to fall into the Acquaintance, and under the Instruction of the most Demonstrative and most Familiar Man in the World, the Famous GALILEO: whose succeſſe being no leſſe upon this his Pupil than upon the reſt of thoſe Illuſtrious and Ingenious Persons that reſorted from all parts to ſit under his Admirable Lectures, he in a ſhort time attained to that Name in the Mathematicks, that he was invited to ROME, Complemented, and Preferred by his then Holineſſe the Eighth URBAN, upon his very firſt Acceſſion to the Papacy, which was in the Year 1623.

§. This Pope being moved with a Paternal Providence for the Concerns of his Subjects in that part of ITALY about BOLOGNA, FERRARA, and COMMACHIO, lying between the Rivers of PO and RENO, which is part of Lo Stato della Chieſa, or the Church Patrimony, appoints this our CASTELLI in the Year 1625, to accompany the Right Honourable Monſignore GORSINI (a moſt obſervant and intelligent perſon in theſe affaires, and at that time Superintendent of the General Draines, and Preſident of ROMAGNA) in the Grand Viſitation which he was then ordered to make concerning the diſorders occaſioned by the Waters of thoſe parts.

§. CASTELLI, having now an Opportunity to employ, yea more, to improve ſuch Notions as he had imbued from the Lectures of his Excellent MASTER, falls to his work with all induſtry: and in the time that his Occaſions detained him in ROMAGNA he perfected the Firſt Book of this his Diſcourſe concerning the Meaſuration of Running Waters. He confeſſeth that he had ſome years before applied himſelf to this part of Practical Geometry, and from ſeveral Obſervations collected part of that Doctrin which at this time he put into Method, and which had procured him the Repute of ſo much Skill that he began
to

THE AUTHOR AND WORK.

to be Courted by sundry Princes, and great Prelates. In particular about the beginning of the Year 1623. and before his Invitation to ROME he was employed by Prince Ferdinando I, Grand Duke of TUSCANY, to remedy the Disorders which at that time happened in the Valley of PISA in the Meadows that lye upon the Banks of Serchio and Fiume Morto: and in the presence of the Grand Duke, Grand Dutchesse Mother, the Commissioners of Sewers, and sundry other Persons in a few hours he made so great a progresse in that affair, as gave his Most Serene Highnesse high satisfaction, and gained himself much Honour.

§. No sooner had he in his fore-mentioned Voiage to ROMAGNA (which was but few Moneths after, in the same Year) committed his Conceptions to paper, but he communicated them to certain of his Friends. In which number we finde Signore Ciampoli Secretary of the Popes Private Affaires; whom in the beginning of the First Book he gratefully acknowledgeth to have been contributory, in his Purse, towards defraying the charge of Experiments; and in his Person, towards the debating and compleating of Arguments upon this Subject. Some few years after the Importunity of Friends, and the Zeal he had for the Publique Good prevailed with him to present the World with his First Discourse, accompanied with a Treatise of the Geometrical Demonstrations of his whole Doctrine. What Reception it found with the Judicious must needs be imagined by any one that hath observed how Novelty and Facility in conjunction with Verity make a Charm of irresistible Operation.

§. New it was, for that no man before him had ever attempted to Demonstrate all the three Dimensions, to wit, the Length, Breadth and Profundity, of this Fluid and Current Element. And he deteſteth such grosse Errours in those few that had undertook to write upon the Subject (of which he instanceth in Frontinus and Fontana, as those that include the rest) and delivereth such singular and unheard-of Paradoxes (for so they sound in Vulgar Eares) as cannot but procure unspeakable delight to his Reader.

§. Easie it is likewise and True; and that upon so Familiar Experiments and Manifest Demonstrations, that I have oft questioned with my self which merited the greater wonder, he, for discovering, or all men that handled the Argument before him for not discovering a Doctrine of such strange Facility and Infalibility. But yet as if our Author designed to oblige the whole World to him by so excellent a Present, he selecteth a Subject that he knew would be carressed by all persons of Nobler Souls, upon the accounts afore-named, and by all Mankind in General, as gratifying them in their much adored Idol Utility. And to render

AN ACCOUNT OF

der his Art the more profitable, he reduceth the lofty, and easie-to-be-mistaken Speculations of the Theory, into certain and facile Directions for Practice; teaching us how to prevent and repaire the Breaches of Seas; and Inundations of Rivers; to draine and recover Fenns and Marches; to divert, conweigh and distribute Waters for the Flowing and Stercoration of Grounds, strengthening of Fortifications, serving of Aquaducts, preserving of Health (by cleansing Streets, and scowring Sewers,) and maintaining of Commerce (by defending Bridges, clearing Rivers, and opening Ports and Channels) with innumerable other Benefits of the like nature. And, that I may omit no circumstance that may recommend my Authour, the Fortune of this his Treatise hath been such, that as if he intended a Plus ultra by it, or as if all men despaired to out-do it, or lastly, as if CASTELLI hath been so great a Master that none have presumed to take Pencil in hand for the finishing of what he Pourfoild, this small Tract like the Arabian Phoenix (of which it is said Unica semper Avis) did for several years together continue single in the World, till that to verifie it to be truly Phœnician, it renewed its Age by undergoing a second Impression. And as if this did not make out the Immortal vertue of it, it hath had Anno 1660 a third Circulation, and risen in this last Edition as it were from the Urne of its Authour; and that so improved by the Addition of a second part, that it promiseth to perpetuate his Merits to all Posterity. To be brief, the meer Fame of this Work resounded the Honourable Name of CASTELLI into all the Corners of Italy; I may say of Europe; insomuch, that, in hopes to reap great benefit by his Art, the respective Grandees of the adjacent Countries courted his Judgment and Advice about their Draining of Fenns, Diversion of Rivers, Evacuation of Ports, Preventing of Inundations, &c. So that every Summer he made one or more of these Journies or Visitations. Particularly, the Senate of Venice consulted him about their Lake; to whom he delivered his Opinion in May, 1641. and upon farther thoughts he presented them with another Paper of Considerations the 20 December following. Prince LEOPOLDO of TUSCANY likewise requested his Advice in the beginning of the ensuing year 1642, which occasioned his Letter to Father Francesco di San Giuseppe, bearing date February 1. To which Signore Bartolotti opposing, he writes a second Letter, directed to one of the Commissioners of Sewers, vindicating his former, and refuting Bartolotti; both which I here give you.

§. The Preferments which his Merits recommended him unto, were first to be Abbot of Cassino, from which he was removed

Anno

THE AUTHOUR AND WORK.

Anno 1640, or thereabouts, unto the Abbey of Santo Benedet-
to Aloyſio; and much about the ſame time preferred to the Dig-
nity of Chief Mathematician to his grand Patron Pope URBAN
VIII. and Publique Profeſſour of Mathematicks in the Uni-
verſity of ROME.

§. Here a Stop was put to the Carrier of his Fortunes; and be-
ing fuller of Honour than of Tears, was by Death, the Importu-
nate Interruption of Generous Deſigns, prevented in doing that
farther Good which the World had good reaſon to promiſe it ſelf
from ſo Profound and Induſtrious a Perſonage, leaving many
Friends and Diſciples of all Degrees and Qualities to lament
his loſſe, and honour his Memory.

§. His ſingular Virtues and Abilities had gained him the
Friendſhip of very many; as to inſtance in ſome, he had con-
tracted ſtrict Amity with Monſignore Maſſei Barberino a Floren-
tine, Praefeſt of the Publique Wayes, and afterwards Pope with
the Name of URBAN VIII. as was ſaid before; with the
above-named Monſignore Corſini Superintendant of the General
Drainers: with Monſignore Piccolomini Arch-Biſhop of Siena;
with Cardinal Serra: with Cardinal Caponi, who hath ſtudied
much and writ well upon this Subject; and with Cardinal Gae-
tano who frequently conſulted with him in his deſign of Drain-
ing the Fens of ROMAGNA. Moreover Prince LEO-
POLDO, and his Brother the Grand Duke had very great
kindneſſe for him; which ſpeaks no ſmall attractions in him,
conſidering him as a favourite of the Family of Barberini, be-
tween whom and the Houſe of Medeci there is an inveterate
Fewd. Amongſt perſons of a lower Quality he acknowledgeth
Signore Ciampoli the Popes Secretary, Sig. Ferrante Ceſarini,
Sig. Giovanni Baſadonna Senator of Venice; and I find menti-
oned Sig. Lana, Sig. Albano, Padre Serafino, Pad. Francesco
de San. Giuſeppe, and many others.

§. The Works in which he will ſurvive to all ſucceeding Ages
are firſt His ſolid and ſober Confutation of the Arguments of
Signore Lodovico dell Columbo, and Signore Vincentio di
Gratia againſt the Tract of Galileo Delle coſe che ſtanno ſopra
Aqua, wherein he vindicates his ſaid Maſter with a Gratitude
that Tutors very rarely reap from the pains they take in Culti-
vating their Pupils. This Apology was firſt Printed Anno 1615.
and was a ſecond time publiſhed, as alſo thoſe of his Antago-
niſts, amongſt the Works of GALILEO, ſet forth by the
Learned Viviani 1656. He hath likewiſe writ ſeveral other
curious Pieces, as I am informed by the moſt Courteous Carolo
Manoleſſi of Bologna; amongſt others an excellent Treatiſe
concerning Colours, which he putteth me in hopes to ſee printed
very

AN ACCOUNT OF

very speedily. And last of all these Discourses and Reflections upon the Mensuration of Running Waters, with the addition of a Second Book, three Epistles, and four Considerations upon the same Argument, which conduce much to Illustrate his Doctrine and Facilitate the Practice of it; and which with a Relation of Monsignore Corsini, make the second part of my First Tome.

§. I might here sally forth into the Citation of sundry Authors of Good Account, that have transmitted his Character to Posterity, but shall confine my self to onely two; the one is of his Master, the other of his Scholar; than whom there cannot be two more competent Judges of his Accomplishments. To begin with his Master, the Quick-sighted, and truly Lyncean

GALILEO, who speaking of his Abilities in Astronomy saith

(a) Nella continuazione dell' Nunzio siderio.

(a) Che la felicità del suo ingegno non la fa bisognosa dell' opera suo. And again, submitting a certain Demonstration, which he intended to divulge, to the Judgment of this our Abbot, he writes to him in this manner: (b) Questo io comunico a V. S. per lettera prima che ad alcun altro, con attenderne principalmente il parer suo, e doppo quello de' nostri Amici discosti, compensiero d' inviarne poi altre Copie ad altri Amici d' Italia, e di Francia, quando io ne venga da lei consigliato: e qui pregandola a farci parte d' alcuna delle sue peregrine speculationi; con sincerissimo affetto, &c. And the most acute Mathematician Signore Evangelista Terricelli, late Professor to the Grand Duke in immediate Succession after **GALILEO**, maketh this

(c) De Motu Aë quantum. Lib. 2. Prop. 37. p. 191.

Honourable and Grateful Mention of him, and his Book: (c) Ommitto magnum illum nutantis Maris motum; Prætereo etiam omnem Fluminum, Aquarumque Currentium tum mensurum, tum usum, quarum omnis doctrina reperta primum fuit ab Abbate **BENEDICTO CASTELLIO** Preceptore meo. Scripsit ille Scientiam suam, & illam non solum demonstratione, verum etiam opere confirmavit, maxima cum Principum & populorum utilitate, majore cum admiratione Philosophorum. Extat illius Liber, vere aureus.

§. I have onely two particulars more to offer the English Reader: The one concerns the Book, and it is this, That after the general Aprobation it hath had in Italy, I cannot but think it deserweth the same Civil Entertainment with us, in regard that it cometh with no lesse Novelty, Facility, Verity, and Utility to us than to those whom the Authour favoured with the Original. Our Rivers and Sewers through Publique Distractions and Private Inroachments are in great disorder, as those Channels for instance which formerly were Navigable unto the very Walls of

York
by S.
and
Conf.
Book
ratio.
here
with
any
them
Lear
Treat
Doct
must
Secen
he w
Deat
Prooj
clusio
6.
fire
for
wing
the
a M
thor
Tim
Pri
end
and

THE AUTHOR AND WORK.

York and Salisbury, &c: Our Ports are choaked and obstructed by Shelves and Settlements: Our Fenns do in a great part lie waste and unimproved: Now all these may be (and, as I find by the Confession of some whose Practises upon the Copy of the First Book onely of our Author hath got them both Money and Reputation, in part have been) remedied by the Ways and Means he here sets down. The truth is the Argument hath been past over with an Universal Silence; so that to this day I have not seen any thing that hath been written Demonstratively and with Mathematical Certainty concerning the same; save onely what this Learned Prelate hath delivered of his Own Invention in these Treatises: who yet hath so fully and plainly handled the Whole Doctrine, that I may affirm his Work to be every way absolute. It must be confest the Demonstration of the Second Proposition of the Second Book did not well please the Author, and had he lived he would have supplied that defect, but being prevented by Death, the Reader must content himself with the Mechanical Proof that he giveth you of the truth of so Excellent a Conclusion.

§. The other particular that I am to offer is, that out of my desire to contribute what lyeth in me to the compleating of this Piece for English Practise, I have exceeded my promise not onely in giving you the Second and following Books which were not extant at the time of tendring my Overtures, but also in that I have added a Map or Plat of all the Rivers, Lakes, Fenns, &c. mentioned thorowout the Work. And if I have not kept touch in point of Time, let it be considered that I am the Translator and not the Printer. To conclude, according to your acceptance of these my endeavours, you may expect some other Tracts of no lesse Profit and Delight.

Farewell.

T. S.

ERRATA of the *second* PART of the *first* TOME.

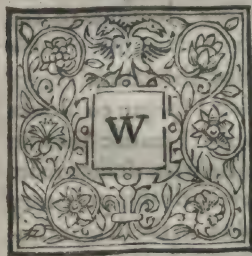
In PREFACE, read *Ferdinando II.* *ibid.* *P. Aqua.*

PAGE 2. LINE 26, for *mult* read *much*. P. 3. l. 22, *r.* and let. l. 25, *r.* water, from l. 41. *r.* Tappe, (*as every where else*). Page 4. l. 18, *r.* cords. Page 6. l. 9, *r.* acquire, or. Page 9. l. 1, *r.* irreperable. P. 10. l. 13, *r.* diffimbogement. For Page 17. *r.* P. 15. P. 15. l. 17, *r.* in. l. 36, *r.* is as. l. 38, *r.* Panaro. P. 17. l. 12, *Giulio*. l. 17, *r.* Measurers. l. 25, *r.* measured it, *r.* necessarily. P. 23. l. 19, *r.* for help. for Page 31. *r.* P. 32. P. 24. l. 14, *r.* to. l. 17, *r.* namely, of the. l. 23, *r.* easie. P. 25. l. 38, *r.* Cock. p. 29. l. 7, *r.* lasted, . p. 31. l. 32, *r.* Soe. p. 41. l. 20, *r.* to the line. p. 48. l. 19, *r.* us the * *id.* *Figure false* p. 52. l. 30, and 31, for Theorem *r.* Proposition. p. 53. l. 29, *r.* again. p. 57. l. 19, *r.* same if. l. 44, *r.* bodily. p. 58. l. 9, *r.* gathering. l. 40, *omit*; p. 60. l. 2, *omit*, if. p. 65. l. 1, *r.* tide *dele*; p. 66. l. 35, *r.* Stoppage of. p. 68. l. 12, for Lords the *r.* Lords. l. *ult.* for they *r.* it. p. 69. l. 14, *r.* to one. *id.* carried *dele* to. p. 71. l. 20, *r.* and that. l. 25, *r.* Braces; in. l. 29, *r.* Braces. l. 44, *r.* the *Brent*. p. 72. l. 23, *r.* *Serene Highness*. p. 73. l. 24, *r.* deliberation: l. 26, for summer. Moddel. l. 40, *r.* Months. p. 79. l. 18, *r.* that into. p. 82. l. 22, *dele*; p. 85. l. 9, 10, *dele* a free drame. p. 88. l. 5, *r.* Palmes. p. 89. l. 8, *r.* Princces. p. 92. l. 3, *r.* Discourses. p. 93. l. 31, *r.* Tautologic. p. 94. l. 9, *r.* miracle; p. 97. l. 13, *r.* weighty. p. 101. l. 21, *r.* Marrara. p. 107. l. 28, *r.* Patrimony. l. 40, *r.* above. p. 111. l. 16, *r.* said. For p. 43. *r.* p. 114. p. 114. l. 35, *r.* of 200. l. 41, *r.* closed. p. 115. l. 29, *r.* constant;



OF THE
MENSURATION
OF
Running Waters.

LIB. I.



That, and of how great moment the consideration of *Motion* is in natural things, is so manifest, that the Prince of *Peripateticks* pronounced that in his Schools now much used Sentence: *Ignorato motu, ignoratur natura*. Thence it is that true Philosophers have so travailed in the contemplation of the Celestial motions, and in the speculation of the motions of

Animals; that they have arrived to a wonderful height and sublimity of understanding. Under the same Science of *Motion* is comprehended all that which is written by Mechanicians concerning Engines moving of themselves, *Machins* moving by the force of Air, and those which serve to move weights and immense magnitudes with small force. There appertaineth to the Science of *Motion* all that which hath been written of the alteration not onely of Bodies; but of our Minds also; and in sum, this ample matter of *Motion* is so extended and dilated, that there are few things which fall under mans notice; which are not conjoynd with *Motion*, or at least depending thereupon; or to the knowledge thereof directed; and of almost every of them; there hath been written and composed by sublime wits, learned Treatises and Instructions.

¶ b b b

And

And because that in the years past I had occasion by Order of our Lord Pope *Urban 8.* to apply my thoughts to the motion of the Waters of Rivers, (a matter difficult, most important, and little handled by others) having concerning the same observed some particulars not well observed, or considered till now, but of great moment both in publick and private affairs; I have thought good to publish them, to the end that ingenious spirits might have occasion to discusse more exactly then hitherto hath been done, so necessary and profitable a matter, and to supply also my defects in this short and difficult Tractate. Difficult I say, for the truth is, these knowledges, though of things next our senses, are sometimes more abstruse and hidden, then the knowledge of things more remote; and much better, and with greater exquisiteness are known the motions of the Planets, and Periods of the Stars, than those of Rivers and Seas: As that singular light of Philosophie of our times, and my Master *Signore Galileo Galilei* wisely observeth in his Book concerning the Solar spots. And to proceed with a due order in Sciences, I will take some suppositions and cognitions sufficiently clear; from which I will afterwards proceed to the deducing of the principal conclusions. But to the end that what I have written at the end of this discourse in a demonstrative and Geometrical method, may also be understood of those which never have applyed their thoughts to the study of Geometry; I have endeavoured to explain my conceits by an example, and with the consideration of the natural things themselves, must after the same order in which I began to doubt in this matter; and have placed this particular Treatise here in the beginning; adverting nevertheless, that he who desires more full and absolute solidity of Reasons, may overpass this prefatory discourse, and onely consider what is treated of in the demonstrations placed towards the end, and return afterwards to the consideration of the things collected in the *Corollaries* and *Appendices*; which demonstrations notwithstanding, may be pretermitted by him that hath not seen at least the first six Books of the *Elements* of *Euclid*; so that he diligently observeth that which followeth.

I say therefore, that having in times past, on divers occasions heard speak of the measures of the waters of Rivers, and Fountains, saying, such a River is two or three thousand feet of water; such a spring-water is twenty, thirty, or forty inches, &c. Although in such manner I have found all to treat thereof in word and writing, without variety, and as we are wont to say, *constanti sermone*, yea even Artists and Ingeneers, as if it were a thing that admitted not of any doubt, yet howsoever I remained still infolded in such an obscurity, that I well knew I understood

derstood nothing at all, of that which others pretended full and clearly to understand. And my doubt arose from my frequent observation of many Trenches and Channels, which carry water to turn Mills; in which Trenches, and Channels, the water being measured, was found pretty deep; but if afterwards the same water was measured in the fall it made to turn the Wheel of the Mill, it was much lesse, not amounting often to the tenth part, nor sometimes to the twentieth, insomuch, that the same running water came to be one while more, another while less in measure, in divers parts of its Channel; and for that reason this vulgar manner of measuring running Waters, as indeterminate and uncertain, was by me justly suspected, the measure being to be determinate, and the same. And here I freely confesse that I had singular help to resolve this difficulty from the excellent & accurate way of discoursing, as in allover matters, so also in this, of the Right Honourable and Truly Noble Signior *Ciampoli*, Secretary of the Popes secret affairs. Who moreover, not sparing for the costs of the same, generously gave me occasion a few years past to try by exact experiments that which past concerning this particular. And to explain all more clearly with an example; we suppose a Vessel filled with Water, as for instance a Butt, which is kept full, though still water runneth out, and the Water run out by two Taps equal of bignesse, one put in the bottom of the Vessel, and the other in the upper part; it is manifest that in the time wherein from the upper part shall issue a determinate measure of water from the inferiour part there shall issue four, five, and many more of the same measures, according to the difference of the height of the Taps, and the distance of the upper Tap from the Superficies and level of the water of the Vessel: and all this will alwayes follow; though, as hath been said, the Taps be equal, and the water in discharging keep the said Taps alwayes full. Where first we note, that, although the measure of the Taps be equal, nevertheless there issueth from them in equal times unequal quantities of water, And if we should more attentively consider this businesse, we should find, that the water by the lower Tap, runneth and passeth with much greater velocity, then it doth by the upper; whatever is the reason. If therefore we would have such a quantity of Water discharge from the upper tap, as would discharge from the neather in the same time, it is plain, that either the upper Taps must be multiplyed in such sort, that so many more Taps in number be placed above than below, as the neather tap shall be more swift than the upper, or the upper Tap made so much bigger than the neather, by how much that beneath shall be more swift than that above; and so then in equal times, the same quantity of Water shall discharge from the upper, as doth from the neather part.

B b b a

I will declare my self by another example. If we should imagine, that two cords or lines of equal thickness, be drawn through two holes of equal bore; but so that the first pass with quadruple velocity to the second: It is manifest, that if in a determinate time, we shall by the first bore have drawn four Ells of the line, in the same time, by the second hole we shall have drawn but one Ell of cord onely; and if by the first there passe twelve Ells, then through the second there shall passe onely three Ells; and in short the quantity of cord shall have the same proportion to the cord, that the velocity hath to the velocity. And therefore we desiring to compensate the tardity of the second cord, and maintaining the same tardity to draw through the second hole as much cord as through the first, it will be necessary to draw through the second bore four ends of cord; so that the thickness of all the cords by the second hole, have the same proportion to the thickness of the cord which passeth onely by the first, as the velocity of the cord by the first hole hath reciprocally to the velocity of the cords by the second hole. And thus its clear, that when there is drawn through two holes equal quantity of cords in equal time, but with unequal velocity, it will be necessary, that the thickness of all the four cords shall have the same reciprocal proportion to the thickness of the swifter cord, that the velocity of the swifter cord hath to the velocity of the slower. The which is verified likewise in the fluid Element of Water.

And to the end that this principal fundamental be well understood, I will also note a certain observation made my me in the Art of Wyer-drawing, or spinning Gold, Silver, Brasse, and Iron, and it is this; That such Artificers desiring more and more to disgrosse and subtrillize the said Metals, having wound about a Rocket or Barrel, the thread of the Metal, they place the Rocket in a frame upon a stedfast Axis, in such sort that the Rocket may turn about in it self; then making one end of the thread to passe by force through a Plate of Steel pierced with divers holes, greater and lesser, as need requireth, fastning the same end of the thread to another Rocket, they wind up the thread, which passing through a bore less than the thicknesse of the thread, is of force constrained to disgrosse and subtrillize. Now that which is intently to be observed in this busines, is this, That the parts of the thread before the hole, are of such a thicknesse, but the parts of the same thread after it is passed the hole, are of a lesser thicknesse: and yet neverthelesse the masse and weight of the thread which is drawn forth, is ever equal to the masse and weight of the thread which is winded up. But if we should well consider the matter, we should finde, that the thicker the thread before the hole is, than the thread passed the hole, the greater reciprocally is the velocity

velocity of the parts of the thread passed the hole, than the velocity of the parts before the hole: Inſomuch that if *verbi gratia* the thickneſſe of the thread before the hole, were double to the thickneſſe after the hole, in ſuch caſe the velocity of the parts of the thread paſſed the hole, ſhould be double to the velocity of the parts of the thread before the hole; and thus the thickneſſe compenſates the velocity, and the velocity compenſates the thickneſſe. So that the ſame occurreth in the ſolid Metals of Gold, Silver, Braſs, Iron, &c. that eveneth alſo in the fluid Element of Water, and other liquids, namely, That the velocity beareth the ſame proportion to the velocity, that the thickneſſe of the Metal, or Water, hath to the thickneſſe.

And therefore granting this diſcourſe, we may ſay, that as often as two Taps with different velocity diſcharge equal quantities of Water in equal times, it will be neceſſary that the Tap leſſe ſwift be ſo much greater, and larger, than the Tap more ſwift, by how much the ſwifter ſuperates in velocity the ſlower; and to pronounce the Proposition in more proper terms, we ſay, That if two Taps of unequal velocity, diſcharge in equal times equal quantities of Water, the greatneſſe of the firſt ſhall be to the greatneſſe of the ſecond, in reciprocal proportion, as the velocity of the ſecond to the velocity of the firſt. As for example, if the firſt Tap ſhall be ten times ſwifter than the ſecond Tap, it will be neceſſary, that the ſecond be ten times bigger and larger than the firſt; and in ſuch caſe the Taps ſhall diſcharge equall quantities of water in equal times; and this is the principal and moſt important point, which ought to be kept alwayes in minde, for that on it well underſtood depend many things profitable, and worthy of our knowledge.

Now applying all that hath been ſaid neerer to our purpoſe, I conſider, that it being moſt true, that in divers parts of the ſame River or Current of running water, there doth alwayes paſſe equal quantity of Water in equal time (which thing is alſo demonſtrated in our firſt Proposition) and it being alſo true, that in divers parts the ſame River may have various and different velocity; it follows of neceſſary conſequence, that where the River hath leſſe velocity, it ſhall be of greater meaſure, and in thoſe parts, in which it hath greater velocity, it ſhall be of leſſe meaſure; and in ſum, the velocity of ſeveral parts of the ſaid River, ſhall have eternally reciprocal and like proportion with their meaſures. This principle and fundamental well eſtabliſhed, that the ſame Current of Water changeth meaſure, according to its varying of velocity; that is, leſſening the meaſure, when the velocity encreaſeth, and encreaſing the meaſure, when the velocity decreaſeth; I paſſe to the conſideration of many
par-

particular accidents in this admirable matter, and all depending on this sole Proposition, the sense of which I have oft repeated, that it might be well understood.

COROLLARIE I.

ANd first, we hence conclude, that the same Streams of a Torrent, namely, those streams which carry equal quantity of Water in equal times, make not the same depths or measures in the River, in which they enter, unlesse when in the entrance into the River they acquire; or to say better, keep the same velocity; because if the velocities acquired in the River shall be different, also the measures shall be diverse; and consequently the depths, as is demonstrated.

COROLLARIE II.

ANd because successively, as the River is more and more full, it is constituted ordinarily in greater & greater velocity: hence it is that the same streams of the Torrent, that enter into the River, make lesse and lesse depths, as the River grows more and more full; since that also the Waters of the Torrent being entered into the River, go acquiring greater and greater velocities, and therefore diminish in measure and height.

COROLLARIE III.

WE observe also, that while the main River is shallow, if there fall but a gentle rain, it suddenly much increaseth and riseth; but when the River is already swelled, though there fall again another new violent shower, yet it increaseth not at the same rate as before, proportionably to the rain which fell: which thing we may affirm particularly to depend on this, that in the first case, while the River is low, it is found also very slow, and therefore the little water which entereth into it, passeth and runs with little velocity, and consequently occupieth a great measure: But when the River is once augmented, by new water being also made more swift, it causeth the great Flood of water which falleth, to bear a lesse measure, and not to make such a depth.

COROLLARIE IV.

From the things demonstrated is manifest also, that whilst a Torrent entereth into a River, at the time of Ebbe, then the Torrent moveth with such a certain velocity, what ever it be, passing

passing by its extreamest parts, wherewith it communicateth with the River; in which parts, the Torrent being measured, shall have such a certain measure: but the River swelling and rising, also those parts of the Torrent augment in greatness and measure, though the Torrent, in that instant, dil-imbogue no more water than it did before: so that the River being swelled, we are to consider two mouths of the same Torrent, one lesse before the rising, the other greater after the rising, which mouths discharge equal quantities of water in equal times; therefore the velocity by the lesser mouth shall be greater than the velocity by the greater mouth; and thus the Torrent shall be retarded from its ordinary course.

COROLLARIE V.

FROM which operation of Nature proceedeth another effect worthy of consideration; and it is, that the course of the water retarding, as hath been said in those ultimate parts of the Torrent, if it shall happen that the Torrent grow torbid and muddy, and its streame be retarded in such a degree, that it is not able to carry away those minute grains of Earth, which compose the muddiness; in this case the Torrent shall clear away the mud, and carry away the Sand at the bottome of its own Chanel, in the extream parts of its mouth, which raised and voided Sand, shall again afterwards be carried away, when the River abating, the Torrent shall return to move with its primitive velocity.

COROLLARIE VI.

WHilst it is demonstrated, that the same water hath different measures in its Chanel or course, according as it varieth in velocity; so that the measure of the water is alwayes greater, where the velocity is lesser; and on the contrary, the measure lesser, where the velocity is greater: from hence we may most elegantly render the reason of the usual Proverb, *Take heed of the still waters*: For that if we consider the self same water of a River in those parts, wherein it is less swift, and thence called *still* or *smooth* water, it shall be, of necessity, of greater measure than in those parts, in which it is more swift, and therefore ordinarily shall be also more deep and dangerous for passengers; whence it is well said, *Take heed of the still Waters*; and this saying hath been since applied to things moral.

COROLLARIE VII.

Likewise, from the things demonstrated may be concluded, that the windes, which stop a River, and blowing against the Current, retard its course and ordinary velocity shall necessarily amplify the measure of the same River, and consequently shall be, in great part, causes; or we may say, potent con-causes of making the extraordinary inundations which Rivers use to make. And its most certain, that as often as a strong and continual wind shall blow against the Current of a River, and shall reduce the water of the River to such tardity of motion, that in the time wherein before it run five miles, it now moveth but one, such a River will increase to five times the measure, though there should not be added any other quantity of water; which thing indeed hath in it something of strange, but it is most certain, for that look what proportion the waters velocity before the winde, hath to the velocity after the winde, and such reciprocally is the measure of the same water after the winde, to the measure before the winde; and because it hath been supposed in our case that the velocity is diminished to a fifth part, therefore the measure shall be increased five times more than that, which it was before.

COROLLARIE VIII.

WE have also probable the cause of the inundations of Tyber, which betel at Rome, in the time of Alexander the Sixth, & of Clement the Seventh; which innundations came in a serene time, and without great thaws of the Snows; which therefore much puzzled the wits of those times. But we may with much probability affirm, That the River rose to such a height and excrecence, by the retardation of the Waters dependant on the boistrous and constant Winds, that blew in those times, as is noted in the memorials.

COROLLARIE IX.

IT being most manifest, that by the great abundance of Water the Torrents may increase, and of themselves alone exorbitantly swell the River; and having demonstrated that also without new Water, but onely by the notable retardment the River riseth and increaseth in measure, in proportion as the velocity decreaseth: hence it is apparent, that each of these causes being able of it self, and separate from the other to swell the River; when it shall happen that both these two causes conspire the augmentation of the

the River, in such a case there must follow very great and irreparable inundations.

COROLLARIE X.

From what hath been demonstrated, we may with facility resolve the doubt which hath troubled, and still poseth the most diligent, but incautious observers of Rivers, who measuring the Streams and Torrents which fall into another River; as those for instance, which enter into the *Po*, or those which fall into *Tiber*; and having summed the total of these measures, and conferring the measures of the Rivers and Brooks, which fall into *Tiber*, with the measure of *Tiber*, and the measures of those which disimbogue into *Po*, with the measure of *Po*, they find them not equal, as it seems to them, they ought to be; and this is because they have not well noted the most important point of the variation of velocity, and how that it is the most potent cause of wonderfully altering the measures of running Waters; but we most easily resolving the doubt, may say that these Waters diminish the measure, being once entered the principal Channel, because they increase in velocity.

COROLLARIE XI.

Through the ignorance of the force of the velocity of the Water, in altering its measure, & augmenting it when the velocity diminisheth; and diminishing it when the velocity augmenteth: The Architect *Giovanni Fontana*, endeavoured to measure; and had to cause to be measured by his Nephew, all the Brooks and Rivers which discharged their Waters into *Tiber*, at the time of the Inundation; which happened at *Rome* in the year 1598, and published a small Treatise thereof, wherein he summeth up the measures of the extraordinary Water which fell into *Tiber*, and made account that it was about five hundred Ells more than ordinary; and in the end of that Treatise concludeth, that to remove the Inundation wholly from *Rome*, it would be necessary to make two other Channels, equal to that at present, and that lesse would not suffice; and finding afterwards that the whole Stream passed under the Bridge *Quattro-Capi*, (the Arch whereof is of a far less measure then five hundred Ells) concludeth, that under the said Bridge past a hundred fifty one Ells of Water compressed, (I have set down the precise term of compressed Water, written by *Fontana*) wherein I finde many errors.

The first of which is to think that the measures of these Waters compressed in the Channels of those Brooks and Rivers,

C c c c

should

should maintain themselves the same in *Tiber*, which by his leave, is most false, when ever those waters reduced into *Tiber*, retain not the same velocity which they had in the place in which *Fontana* and his Nephew measured them: And all this is manifest from the things which we have above explained; for, if the Waters reduced into *Tiber* increase in velocity, they decrease in measure; and if they decrease in velocity, they increase in measure.

Secondly, I consider that the measures of those Brooks and Rivers, which enter into *Tiber* at the time of Innundation, are not between themselves really the same, when their velocities are not equal, though they have the same names of Ells and Feet; for that its possible that a disingboguement of ten Ells, requadrated (to speak in the phrase of *Fontana*) of one of those Brooks, might discharge into *Tiber* at the time of Innundation, four, ten, and twenty times less Water, than another mouth equal to the first in greatness, as would occur when the first mouth were four, ten, or twenty times less swift than the second. Whereupon, whilst *Fontana* summes up the Ells and Feet of the measures of those Brooks and Rivers into a total aggregate, he commits the same error with him, which would add into one summe, diverse moneys of diverse values, and diverse places, but that had the same name; as if one should say ten Crowns of *Roman* money, four Crowns of Gold, thirteen Crowns of *Florence*, five Crowns of *Venice*, and eight Crowns of *Mantua*, should make the same summe with forty Crowns of Gold, or forty Crowns of *Mantua*.

Thirdly, It might happen that some River or Current in the parts nearer *Rome*, in the time of its flowing, did not send forth more Water than ordinary; and however, its a thing very clear, that whilst the stream came from the superior parts, that same Brook or River would be augmented in measure, as hath been noted in the fourth *Corollary*; in such sort, that *Fontana* might have inculcated, and noted that same River or Current as concurring to the Innundation, although it were therein altogether unconcerned.

Moreover, in the fourth place we must note, That it might so fall out, that such a River not onely was uninteressed in the Innundation, though augmented in measure, but it might I say happen, that it was instrumental to the asswaging the Innundation, by augmenting in the measure of its own Channel; which matter is sufficiently evident; for if it be supposed that the River in the time of flood, had not had of it self, and from its proper springs more Water than ordinary, its a thing certain, that the Water of *Tiber* rising and increasing; also that River, to level it self with the Water of *Tiber*, would have retained some of its

its Waters in its own Chanel, without discharging them into Tyber, or else would have ingorged and swallowed (if I may so say) some of the water of Tyber; and in this case, at the time of Inundation, lesse abundance of water would have come to Rome, and yet neverthelesse the measure of that River would have been increased.

Fifthly, *Fontana* deceiveth himself, when he concludeth, that to remove the Inundation from Rome, it would be necessary to make two other Channels of Rivers, that were as large as that, which is the present one, and that lesse would not suffice, which, I say, is a fallacy: and to convince him easily of his errour, it sufficeth to say, that all the Streams being passed under the Bridge *Quattro-Capi*, as he himself attests, a Channel would suffice only of the capacity of the said Bridge, provided that the water there might run with the same velocity, as it did under the Bridge at the time of Inundation; and on the contrary, twenty Currents of capacity equal to the present one, would not suffice, if the water should run with twenty times lesse velocity, than it made at the time of the Inundation.

Sixthly, to me it seemeth a great weaknesse to say, that there should passe under the Bridge *Quattro-Capi*, an hundred fifty oneells of water compressed; for that I do not understand that water is like Cotton or Wool, which matters may be prest and trod, as it happeneth also to the air, which receiveth compression in such sort, that after that in some certain place a quantity of air shall be reduced to its natural constitution; and having taken up all the said place, yet neverthelesse compressing the first Air with force and violence, it is reduced into far lesse room, and will admit four or six times as much air, as before, as is experimentally seen in the Wind-Gun, invented in our dayes by *M. Vincenzo Vincenti* of *Urbino*, which property of the Air of admittin^g condensation, is also seen in the portable Fountains of the same *M. Vincenzo*: which Fountains spirt the Water on high, by force of the Air compressed, which whilst it seeks to reduce its self to its natural constitution, in the dilation causeth that violence. But the water can never, for any thing I know, crowd, or prest so, as that if before the compression it held or posselt a place, being in its natural constitution, I believe not, I say, that it is possible, by pressing and crowding to make it posselt lesse room, for if it were possible to compress the Water, and make it to occupy a lesse place, it would thence follow, that two Vessels of equal measure, but of unequal height, should be of unequal capacity, and that should hold more water which was higher, also a Cylinder, or other Vessel more high than broad, would containe more water erected, than being laid along; for that being erect

* And as is at large demonstrated by that most excellent and Honourable personage *Mr. Boyle* in the industrious experiment of his Pneumatic Engine.

ed, the water put therein would be more pressed and crowded.

And therefore, in our case, according to our principles we will say, that the water of that Stream passeth all under the said Bridge *Quattro-Capi*, for that being there most swift, it ought of consequence to be less in measure.

And here one may see, into how many errors a man may run through ignorance of a true and real Principle, which once known and well understood, takes away all mists of doubtings, and easily resolveth all difficulties.

COROLLARIE XII.

THrough the same inadvertency of not regarding the variation of velocity in the same Current, there are committed by Ingeniours and Learned men, errors of very great moment (and I could thereof produce examples, but for good reasons I pass them over in silence) when they think, and propose, by deriving new Channels from great Rivers, to diminish the measure of the water in the River, and to diminish it proportionally, according to the measure of the Water which they make to pass through the Channel, as making *v.g.* a Channel fifty foot broad, in which the derived water is to run wast, ten foot deep, they think they have diminished the measure of the Water in the River five hundred feet, which thing doth not indeed so fall out; and the reason is plain; for that the Chanel being derived, the rest of the main River, diminisheth in velocity, and therefore retains a greater measure than it had at first before the derivation of the Chanel; and moreover, if the Chanel being derived, it shall not conserve the same velocity which it had at first in the main River, but shall diminish it, it will be necessary, that it hath a greater measure than it had before in the River; and therefore to accompt aright, there shall not be so much water derived into the Channel, as shall diminish the River, according to the quantity of the water in the Channel, as is pretended.

COROLLARIE XIII.

THIS same consideration giveth me occasion to discover a most ordinary error, observed by me in the businesse of the water of *Ferara*, when I was in those parts, in service of the most Reverend and Illustrious Monsignor *Corfini*; the sublime wit of whom hath been a very great help to me in these contemplations; its very true, I have been much perplexed, whether I should commit this particular to paper, or passe it over in silence, for that I have ever doubted, that the opinion so common and more-

moreover confirmed with a most manifest experiment, may not onely make this my conjecture to be esteemed far from true, but also to discredit with the World the rest of this my Treatise. Nevertheless I have at last resolved not to be wanting to myself, and to truth in a matter of it self, and for other consequences most important; nor doth it seem to me requisite in difficult matters, such as these we have in hand, to religne our selves to the common opinion; since it would be very strange if the multitude in such matters should hit on the truth; nor ought that to be held difficult, in which even the vulgar do know the truth and right; besides that I hope moreover to prove all in such sort, that persons of solid judgment, shall rest fully perswaded, so that they but keep in mind the principal ground and foundation of all this Treatise, and though that which I will propose, be a particular, as I have said, pertaining onely to the interests of *Ferara*; yet neverthelesse from this particular Doctrine well understood, good judgement may be made of other the like cases in general.

I say then, for greater perspecuity, and better understanding of the whole, That about thirteen miles above *Ferara*, near to *Stellata*, the main of *Po*, branching it self into two parts, with one of its Arms it cometh close to *Ferara*, retaining the name of the *Po* of *Ferara*; and here again it divideth it self into two other branches, and that which continueth on the right hand, is called the *Po* of *Argenta*, and of *Primaro*; and that on the left the *Po* of *Volana*. But for that the bed of the *Po* of *Ferara* being heretofore augmented and raised, it followeth that it resteth wholly deprived of the Water of the great *Po*, except in the time of its greater swelling; for in that case, this *Po* of *Ferara* being restrained with a Bank near to *Bondeno*, would come also in the overflowings of the main *Po*, to be free from its Waters. But the Lords of *Ferara* are wont at such time as the *Po* threateneth to break out, to cut the bank; by which cutting, there disgorgeth such a Torrent of Water, that it is observed, that the main *Po* in the space of some few hours abateth near a foot, and all persons that I have spoken with hitherto, moved by this experiment, think that it is of great profit and benefit to keep ready this Vent, and to make use of it in the time of its fullness. And indeed, the thing considered simply, and at the first appearance, it seemeth that none can think otherwise; the rather, for that many examining the matter narrowly, measure that body of Water which runneth by the Channel, or Bed of the *Po* of *Ferara*, and make account, that the body of the Water of the great *Po*, is diminished the quantity of the body of the Water which runneth by the *Po* of *Ferara*. But if we well remember what hath been said in the beginning of the Treatise, and how much the

the variety of the velocities of the said Water importeth, and the knowledge of them is necessary to conclude the true quantity of the running Water, we shall finde it manifest, that the benefit of this Vent is far lesse than it is generally thought: And moreover, we shall finde, if I deceive not my self, that there follow from thence so many mischiefs, that I could greatly incline to believe, that it were more to the purpose wholly to stop it up, than to maintain it open: yet I am not so wedded to my opinion, but that I am ready to change my judgement upon strength of better reasons; especially of one that shall have first well understood the beginning of this my discourse, which I frequently inculcate, because its absolutely impossible without this advertisement to treat of these matters, and not commit very great errors.

I propose therefore to consideration, that although it be true, that whilst the water of the main *Po* is at its greatest height, the Bank and Dam then cut of the *Po* of *Ferara*, and the superior waters having a very great fall into the Channel of *Ferara*, they precipitate into the same with great violence and velocity, and with the same in the beginning, or little lesse, they run towards the *Po* of *Volana*, and of *Argenta* on the sea coasts; yet after the space of some few hours, the *Po* of *Ferara* being full, and the superior Waters not finding so great a declivity there, as they had at the beginning of the cutting, they fall not into the same with the former velocity, but with far lesse, and thereby a great deal lesse Water begins to issue from the great *Po*; and if we diligently compare the velocity at the first cutting, with the velocity of the Water after the cutting made, and when the *Po* of *Ferara* shall be full of Water, we shall finde perhaps that to be fifteen or twenty times greater than this, and consequently the Water which issues from the great *Po*, that first impetuosity being past, shall be onely the fifteenth or twentieth part of that which issued at the beginning; and therefore the Waters of the main *Po* will return in a small time almost to the first height. And here I will pray those who rest not wholly satisfied with what hath been said, that for the love of truth, and the common good, they would please to make diligent observation whether in the time of great Floods, the said Bank or Dam at *Bondeno* is cut, and that in few hours the main *Po* diminisheth, as hath been said about a foot in its height; that they would observe I say, whether, a day or two being past, the Waters of the main *Po* return almost to their first height; for if this should follow, it would be very clear, that the benefit which resulteth from this diversion or Vent, is not so great as is universally presumed; I say, it is not so great as is presumed, because, though it be granted for true, that the Waters of the main *Po*, abate at the beginning of the

the Vent, yet this benefit happens to be but temporary and for a few hours: If the rising of *Po*; and the dangers of breaking forth were of short duration, as it ordinarily befallerh in the overflowings of Torrents, in such a case the profit of the Vent would be of some esteem: But because the swellings of *Po* continue for thirty, or sometimes for forty dayes, therefore the gain which results from the Vent proveth to be inconsiderable. It remaineth now to consider the notable harms which follow the said Sluice or Vent; that so reflection being made, and the profit and the detriment compared, one may rightly judge, and choose that which shall be most convenient. The first prejudice therefore which ariseth from this Vent or Sluice, is; That the Channels of *Ferara*, *Primaro*, and *Volana* filling with Water, all those parts from *Bondeno* to the Sea side are alarmed, and endangered thereby. Secondly, The Waters of the *Po* of *Primaro* having free ingresse into the upper Valleys, they fill them to the great damage of the Fields adjacent, and obstruct the course of the ordinary Trenches in the same Valleys; insomuch that all the care, cost, and labour about the draining, and freeing the upper Valleys from Water, would also become vain and ineffectual. Thirdly, I consider that these Waters of the *Po* of *Ferara* being passed downwards towards the Sea, at the time that the main *Po* was in its greater excreescences and heights, it is manifest by experience, that when the great *Po* diminisheth, then these Waters passed by the *Po* of *Ferara* begin to retard in their course, and finally come to turn the current upwards towards *Stellata*, resting first in the intermediate time, almost fixed and standing, and therefore depositing the muddiness, they fill up the Channel of the River or Current of *Ferara*. Fourthly and lastly, There followeth from this same diversion another notable damage, and it is like to that which followeth the breaches made by Rivers; near to which breaches in the lower parts, namely below the breach, there is begot in the Channel of the River, a certain ridge or shelf, that is, the bottom of the River is raised, as is sufficiently manifest by experience; and thus just in the same manner cutting the Bank at *Bondeno*, there is at it were a breach made, from which followeth the rising in the lower parts of the main *Po*, being past the mouth of *Pamaro*; which thing, how pernicious it is, let any one judge that understandeth these matters. And therefore both for the small benefit, and so many harms that ensue from maintaining this diversion, I should think it were more sound advice to keep that Bank alwaies whole at *Bondeno*, or in any other convenient place, and not to permit that the Water of the Grand *Po* should ever come near to *Ferara*.

COROLLARIE XIV.

* *Artesia*.

IN the Grand Rivers, which fall into the Sea, as here in *Italy* *Po*, *Adige*,* and *Arno*, which are armed with Banks against their excrescencies, its observed that far from the Sea, they need Banks of a notable height; which height goeth afterwards by degrees diminishing; the more it approacheth to the Sea-coasts; in such sort, that the *Po*, distant from the Sea about fifty or sixty miles at *Ferara*, shall have Banks that be above twenty feet higher than the ordinary Water-marks; but ten or twelve miles from the Sea, the Banks are not twelve feet higher than the said ordinary Water-marks, though the breadth of the River be the same, so that the excrescence of the same Innundation happens to be far greater in measure remote from the Sea, then near; and yet it should seem, that the same quantity of Water passing by every place, the River should need to have the same altitude of Banks in all places: But we by our Principles and fundamentals may be able to render the reason of that effect, and say; That that excess of quantity of Water, above the ordinary Water, goeth alwaies acquiring greater velocity; the nearer it approacheth the Sea, and therefore decreaseth in measure, and consequently in height. And this perhaps might have been the cause in great part, why the *Tyber* in the Innundation *Anno 1578*. issued not forth of its Channel below *Rome* towards the Sea.

COROLLARIE XV.

FROM the same Doctrine may be rendred a most manifest reason why the falling Waters go lessening in their descent, so that the same falling Water, measured at the beginning of its fall, is greater, and bigger, and afterwards by degrees lesseneth in measure the more it is remote from the beginning of the fall. Which dependeth on no other, than on the acquisition, which it successively makes of greater velocity; it being a most familiar conclusion among Philosophers, that grave bodies falling, the more they remove from the beginning of their motion, the more they acquire of swiftnesse; and therefore the Water, as a grave body, falling, gradually velocitates, and therefore decreaseth in measure, and lesseneth.

COROLLARIE XVI.

AND on the contrary, the spiritings of a Fountain of Water, which spring on high, work a contrary effect; namely in

in the beginning they are small, and afterwards become greater and bigger; and the reason is most manifest, because in the beginning they are very swift, and afterwards gradually relent their impetuosity, and motion; so that in the beginning of the excursion that they make, they ought to be small, and afterwards to grow bigger, as in the effect is seen.

APPENDIX. I.

INTO the error of not considering how much the different velocities of the same running water in several places of its current, are able to change the measure of the same water, and to make it greater, or less, I think, if I be not deceived, that *Ginlio Frontino* a noble antient Writer, may have fallen in the Second Book which he writ, of the Aqueducts of the City of *Rome*: Whilst finding the measure of the Water *Commentariis* lesse than it was in *erogatione* 1263. *Quinaries*, he thought that so much difference might proceed from the negligence of the Measures; and when afterwards with his own industry he measured the same water at the beginnings of the Aqueducts, finding it near 10000. *Quinaries* bigger than it was in *Commentariis* he judged, that the overplus was imbeziled by Ministers and Partakers; which in part might be so, for it is but too true, that the publique is almost alwayes defrauded; yet neverthelesse, I verily believe withal, that besides the frauds of these Officers, the velocities of the water in the place wherein *Frontino* measured, it might be different from those velocities, which are found in other places before measured by others; and therefore the measures of the waters might, yea ought necessarily to be different, it having been by us demonstrated, that the measures of the same running water have reciprocal proportion to their velocities. Which *Frontino* not well considering, and finding the water in *Commentariis* 12755. *Quinaries* in *erogatione* 14018, and in his own measure *ad capita ductuum*, at the head of the fountain 12755. *Quinaries*, or thereabouts, he thought, that in all these places there past different quantities of water; namely, greater at the fountain head then that which was in *Erogatione*, and this he judged greater than that which was in *Commentariis*.

* *Commentariis* beareth many senses, but in this place signifieth a certain Register of the quantities of the Waters in the several publique Aqueducts of *Rome*; which word I find frequently used in the Law-books of antient Civilians: And by *erogation* we are to understand the distribution or delivering out of those stores of Water.

APPENDIX II.

Like mistake chanced lately in the Aqueduct of *Acqua-Paola*, which Water should be 2000 Inches, and so many effectively ought to be allowed; and it hath been given in

D d d d

so to be by the Signors of *Bracciano* to the *Apostolick-Chamber*; and there was a measure thereof made at the beginning of the *Aqueduct*; which measure proved afterwards much lesse and short, considered and taken in *Rome*, and thence followed disorders and great disorders, and all because this property of *Running-Waters*, of increasing in measure, where the velocity decreased; and of diminishing in measure, where the velocity augmented, was not lookt into.

APPENDIX III.

A Like error, in my judgement, hath been committed by all those learned men, which to prevent the diversion of the *Reno* of *Elogna* into *Po* by the Channels, through which it at present runneth, judged, that the *Reno* being in its greater exersence about 2000 feet, and the *Po* being near 1000. feet broad, they judged, I say, that letting the *Reno* into *Po*, it would have raised the Water of *Po* two feet; from which rise, they concluded afterwards most exorbitant disorders, either of extraordinary Inundations, or else of immense and intolerable expences to the people in raising the Banks of *Po* and *Reno*, and with such like weaknesses, often vainly disturbed the minds of the persons concerned: But now from the things demonstrated, it is manifest, That the measure of the *Reno* in *Reno*, would be different from the measure of *Reno* in *Po*; in case that the velocity of the *Reno* in *Po*, should differ from the velocity of *Reno* in *Reno*, as is more exactly determined in the fourth Proposition.

APPENDIX IV.

NO less likewise are those Ingeneers and Artists deceived, that have affirmed, That letting the *Reno* into *Po*, there would be no rise at all in the Water of *Po*: For the truth is, That letting *Reno* into *Po*, there would alwaies be a rising; but sometimes greater, sometimes lesse, as the *Po* shall have a swifter or slower Current; so that if the *Po* shall be constituted in a great velocity, the rise will be very small; and if the said *Po* shall be slow in its course, then the rise will be notable.

APPENDIX V.

ANd here it will not be besides the purpose to advertise, That the measures, partments, and distributions of the Waters of *Fountains*, cannot be made exactly, unless there be considered

sidered; besides the measure, the velocity also of the Water; which particular not being thorowly observed, is the cause of continual miscarriages in such like affairs.

APPENDIX VI.

Like consideration ought to be had with the greater diligence, for that an error therein is more prejudicial; I say, ought to be had by those which part and divide VVaters; for the watering of fields, as is done in the Territories of *Brescia, Bergamo, Crema, Pavia, Lodigiano, Cremona*, and other places: For if they have not regard to the most important point of the variation of the velocity of the VVater, but onely to the bare Vulgar measure, there will alwaies very great disorders and prejudices ensue to the persons concerned.

APPENDIX VII.

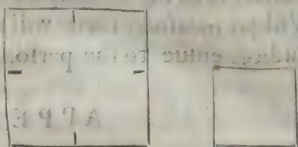
IT seemeth that one may observe, that whilst the Water runneth along a Channel, Current, or Conduit, its velocity is retarded, withheld, and impeded by its touching the Bank or side of the said Channel or Current; which, as immoveable, not following the motion of the VVater, interrupteth its velocity; From which particular, being true, as I believe it to be most true, and from our considerations, we have an occasion of discovering a very nice mistake, into which those commonly fall who divide the VVaters of Fountains. VVhich division is wont to be, by what I have seen here in *Rome*, performed two wayes; The first of which is with the measures of like figures, as Circles, or Squares, having cut through a Plate of metal several Circles or Squares, one of half an inch, another of one inch, another of two, of three, of four, &c. with which they afterwards adjust the Cocks to dispence the VVaters. The other manner of dividing the VVaters of Fountains, is with rectangle parallelograms, of the same height, but of different Bases, in such sort likewise, that one parallelogram be of half an inch, another of one; two, three, &c. In which manner of measuring and dividing the Water, it should seem, that the Cocks being placed in one and the same plain, equidistant from the level, or superior superficies of the water of the Well; and the said measures being most exactly made, the VVater ought consequently also to be equally divided, and parted according to the proportion of the measures. But if we well consider every particular, we shall finde, that the Cocks, as they successively are greater, discharge alwaies more VVater than the just quantity, in comparison of

D d d d 2

the

the lesser; that is, to speak more properly, The VVater which passeth through the greater Cock, hath alwaies a greater proportion to that which passeth through the lesser, than the greater Cock hath to the lesser. All which I will declare by an example.

Let there be supposed for more plainness two Squares; (the same may be understood of Circles, and other like Figures) The first Square is, as we will suppose, quadruple to the other; and these Squares are the mouths of two Cocks; one of four inches, the other of one: Now its manifest by what hath been said, that the VVater which passeth by the less Cock, findeth its velocity impeded in the circumference of the Cock; which impediment is measured by the said circumference. Now it is to be considered, that if we would have the Water which passeth through the greater Cock, to be onely quadruple to that which passeth through the lesse, in equal spaces of time, it would be necessary, that not onely the capacity and the measure of the greater Cock be quadruple to the lesser Cock, but that also the impediment be quadrupled. Now in our case it is true, That the belly and mouth of the Cock is quadrupled, and yet the impediment is not quadrupled, but is onely doubled; seeing that the circumference of the greater Square, is onely double to the circumference of the lesser Square; for the greater circumference containeth eight of those parts, of which the lesser containeth but four, as is manifest by the described Figure; and for that cause there shall pass by the greater Cock, above four times as much VVater, as shall pass by the lesser Cock.



The like errorr occurreth also in the other manner of measuring the VVater of a Fountain, as may easily be collected from what hath been said and observed above.

APPENDIX VIII.

THe same contemplation discovereth the errorr of those Architects, who being to erect a Bridge of sundry Arches over a River, consider the ordinary breadth of the River, which being v. g. forty fathom, and the Bridge being to consist of four Arches, it sufficeth them, that the breadth of all the four Arches taken together, be forty fathom; not considering that in the ordinary Channel of the River, the Water hath onely two impediments which retard its velocity; namely, the touching and gliding along the two sides or shores of the River: but the

the same water in passing under the Bridge, in our case meeteth with eight of the same impediments, bearing, and thrusting upon two sides of each Arch (to omit the impediment of the bottom, for that it is the same in the River, and under the Bridge) from which inadvertency sometimes follow very great disorders, as quotidian practice shews us.

APPENDIX IX.

IT is also worthy to consider the great and admirable benefit that those fields receive, which are wont to drink up the Rain-water with difficulty, through the height of the water in the principal Ditches; in which case the careful Husbandman cutteth away the reeds and rushes in the Ditches, through which the waters pass; whereupon may be presently seen, so soon as the reeds and rushes are cut, a notable Ebb in the level of the water in the Ditches; insomuch that sometimes it is observed, that the water is abated after the said cutting a third and more, of what it was before the cutting. The which effect seemingly might depend on this, That, before those weeds took up room in the Ditch, and for that cause the water kept a higher level, and the said Plants being afterwards cut and removed, the water came to abate, possessing the place that before was occupied by the weeds: Which opinion, though probable, and at first sight satisfactory, is nevertheless insufficient to give the total reason of that notable abatement which hath been spoken of: But it is necessary to have recourse to our consideration of the velocity in the course of the water, the chiefest and true cause of the variation of the measure of the same Running-Water; for, that multitudes of reeds, weeds, and plants dispersed through the current of the Ditch, do chance notably to retard the course of the water, and therefore the measure of the water increaseth; and those impediments removed, the same water gaineth velocity, and therefore decreaseth in measure, and consequently in height.

And perhaps this point well understood, may be of great profit to the fields adjacent to the Pontine Fens, and I doubt not but if the River *Ninfa*, and the other principal Brooks of those Territories were kept well cleansed from weeds, their waters would be at a lower level, and consequently the drains of the fields would run into them more readily; it being alwayes to be held for undoubted, that the measure of the water before the cleansing, hath the same proportion to the measure after cleansing, that the velocity after the cleansing hath to the velocity before the cleansing: And because those weeds being cleansed
away,

away, the course of the water notably increaseth, it is therefore necessary that the said water abate in measure, and become lower.

APPENDIX. X.

WE having above observed some errors that are committed in distributing the waters of Fountains, and those that serve to water fields; it seemeth now fit, by way of a close to this discourse, to advertise by what means these divisions may be made justly and without error. I therefore think that one might two severall wayes exquisitly divide the water of Fountains; The first would be by diligently examining, First, how much water the whole Fountain dischargeth in a determinate time, as for instance: How many Barrels, or Tuns it carrieth in a set time; and in case you are afterwards to distribute the water, distribute it at the rate of so many Barrels or Tuns, in that same time; and in this case the participants would have their punctual shares: Nor could it ever happen to send out more water, than is reckoned to be in the principal Fountain; as befeel *Giulio Frontino*, and as also it frequently happeneth in the Modern Aqueducts, to the publick and private detriment.

The other way of dividing the same waters of a Fountain, is also sufficiently exact and easie, and may be, by having one onely size for the Cock or Pipe, as suppose of an inch, or of half an inch; and when the case requireth to dispence two, three, and more inches, take so many Cocks of the said measure as do evacuate the water, which is to be emitted; and if we are to make use onely of one greater Cock, we being to place one to discharge for example four inches; and having the former sole measure of an inch, we must make a Cock that is bigger, its true, than the Cock of one inch; but not simply in a quadruple proportion, for that it would discharge more than just so much water, as hath been said above; but we ought to examine diligently how much water the little Cock emitteth in an hour; and then enlarge, and contract the greater Cock, so, that it may discharge four times as much water as the lesser in the same time; and by this means we shall avoid the disorder hinted in the seventh Appendix. It would be necessary nevertheless, to accommodate the Cocks of the Cistern so, that the level of the water in the Cistern may alwayes rest at one determinate mark above the Cock, otherwise the Cocks will emit sometimes greater, and sometimes lesse abundance of water: And because it may be that the same water of the Fountain may be sometimes more abundant, sometimes less; in such case it will be necessary to

to adjust the Cistern so, that the excess above the ordinary water, discharge into the publick Fountains, that so the particular participants may have alwayes the same abundance of water.

APPENDIX XI.

Much more difficult is the division of the waters which serve to water the fields; it not being possible to observe so commodiously, what quantity of water the whole Ditch send forth in one determinate time, as may be done in Fountains: Yet nevertheless, if the second proposition by us a little below demonstrated, be well understood, there may be thence taken a very safe and just way to distribute such waters. The Proposition therefore by us demonstrated is this; If there be two Sections, (namely two mouths of Rivers) the quantity of the water which passeth by the first, hath a proportion to that which passeth by the second, compounded of the proportions of the first Section to the second, and of the velocity through the first, to the velocity through the second. As I will declare for example by help of practice, that it may be understood by all, in a matter so important. Let the two mouths of the Rivers be A, and B, and let the mouth A be in measure and content thirty two feet, and the mouth B, eight feet. Here you must take notice, that it is not alwayes true, that the Water which passeth by A, hath the same proportion to that which passeth by B, that the mouth A hath to the mouth B; but onely when the velocityes by each of those passages are equal: But if the velocityes shall be unequal, it may be that the said mouths may emit equal quantity of Water in equal times, though their measure be unequal; and it may be also, that the bigger doth discharge a greater quantity of Water: And lastly, it may be, that the less mouth discharge more Water than the greater; and all this is manifest by the things noted in the beginning of this discourse, and by the said second Proposition. Now to examine the proportion of the Water that passeth by one Ditch, to that which passeth by another, that this being known, the same Waters and mouths of Ditches may be then adjusted; we are to keep account not onely of the greatness of the mouths or passages of the Water; but of the velocity also; which we will do, by first finding two numbers that have the same proportion between themselves,

A. 32.

B. 8.

31. 8. 4

selves, as have the mouths, which are the numbers 32 and 8 in our example: Then this being done, let the velocity of the Water by the passages A and B, be examined (which may be done keeping account what space a piece of Wood, or other body that swimmeth, is carried by the stream in one determinate time; as for instance in 50 pulses) and then work by the golden Rule, as the velocity by A, is to the velocity by B, so is the number 8, to another number, which is 4. It is clear by what is demonstrated in the said second Proposition, that the quantity of water, which passeth by the mouth A, shall have the same proportion of that which passeth by the mouth B, that 8 hath to 4. Such proportion being composed of the proportions of 32 to 8, and of 8 to 4; namely, to the greatness of the mouth A, to the greatness of the mouth B, and of the velocity in A, to the velocity in B. This being done, we must then contract the mouth which dischargeth more then its just quantity of water, or enlarge the other which dischargeth less, as shal be most commodious in practice, which to him that hath understood this little that hath been delivered, will be very asie.

A. 32.

B. 8.

32. 8. 4.

APPENDIX XII.

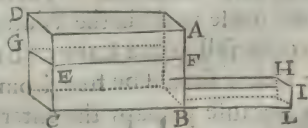
THese operations about Water, as I have hitherto on sundry occasions observed, are involved in so many difficulties, and such a multiplicity of most extravagant accidents, that it is no marvel if continually many, and very important errors be therein committed by many, and even by Ingenieurs themselves, and Learned-men; and because many times they concern not onely the publique, but private interests: Hence it is, that it not onely belongeth to Artists to treat thereof, but very oft even the vulgar themselves pretend to give their judgement therein: And I have been troubled many times with a necessity of treating, not onely with those, which either by practice, or particular study, understood somewhat in these matters; but also with people wholly void of those notions, which are necessary for one that would on good grounds discourse about this particular; and thus many times have met with more difficulty in the thick skulls of men, than in precipitous Torrents, and vast Fennes. And in particular, I had occasion some years past to go see the Cave or Emissary of the Lake of Perugia, made many years ago by Braccio Fortebraccio, but for that it was with great ruines by Time decayed, and rendred unuseful, it was repaired with industry

dustry truly heroicall and admirable, by Monsignor *Maffei Barberino*, then Prefect for the Wayes, and now Pope. And being necessitated, that I might be able to walk in the Cave, and for other causes, I let down the Sluices of the said Cave, at the mouth of the Lake: No sooner were they stopt, but a great many of the people of the Towns and Villages coasting upon the Lake flocking thither, began to make grievous complaints, that if those Sluices were kept shut, not onely the Lake would want its due Vent, but also the parts adjacent to the Lake would be overflowed to their very great detriment. And because at first appearance their motion seemed very reasonable, I found my self hard put to it, seeing no way to perswade such a multitude, that the prejudice which they pretended I should do them by keeping the Sluices shut for two dayes, was absolutely insensible; and that by keeping them open, the Lake did not ebb in the same time so much as the thickness of a sheet of Paper: And therefore I was necessitated to make use of the authority I had, and so followed my business as cause required, without any regard to that Rabble tumultuously assembled. Now when I am not working with Mattock or Spade, but with the Pen and Discourse, I intend to demonstrate clearly to those that are capable of reason, and that have well understood the ground of this my Treatise, that the fear was altogether vain which those people conceited. And therefore I say, that the Emissary or Sluice of the Lake of *Pernugia*, standing in the same manner as at present, and the water passing thorow it with the same velocity as now; to examine how much the Lake may abate in two days space, we ought to consider, what proportion the superficies of the whole Lake hath to the measure of the Section of the Emissary, and afterwards to infer, that the velocity of the water by the Emissary or Sluice, shall have the same proportion to the abatement of the Lake, and to prove thorowly and clearly this discourse, I intend to demonstrate the following Proposition.

Suppose a Vessel of any bignesse, and that it hath an Emissary or Cock, by which it dischargeth its water. And look, what proportion the superficies of the vessel hath to the measure of the section of the cock, such proportion shall the velocity of the Water in the Cock have to the abatement of the Lake. Let the

Vessel be *A B C D*, *H I L B*, through which the Water runneth, the superficies of the Water in the Vessel *A D*, and the section of the Cock *H L*: and let the Water in the Vessel be supposed to have falne in one determinate time from *A* to *E*.

E e e e



I say that the proportion of the superficies of the Vessel AD is in proportion to the measure of the section of the Emissary HL, as the velocity of the Emissary or Cock to the line AF; which is manifest, for that the Water in the Vessel moving by the line AF; as far as F, and the whole mass of Water AG discharging it self, and in the same time the same quantity of Water being discharged by the section of the Emissary HL; it is necessary by what I have demonstrated in the third Proposition, and also explained in the beginning of this Treatise, that the velocity by the Emissary or Cock be in proportion to the velocity of the abatement, as the superficies of the Vessel to the measure of the section of the Emissary, which was to be demonstrated.

That which hath been demonstrated in the Vessel, falls out exactly also in our Lake of *Perugia*, and its Emissary; and because the immensity of the superficies of the Lake is in proportion to the superficies of the Emissary or Sluice, as many millions to one, as may be easily calculated; it is manifest, that such abatement shall be imperceptible, and almost nothing, in two dayes space, nay in four or six: and all this will be true, when we suppose that for that time there entreth no other Water into the Lake from Ditches or Rivolets, which falling into the Lake would render such abatement yet less.

Now we see, that it's necessary to examine such abatements and risings, with excellent reasons, or at least, with accurate experiments, before we resolve and conclude any thing; and how farre the vulgar are distant from a right judgement in such matters.

APPENDIX XIII.

FOR greater confirmation of all this which I have said, I will instance in another like case, which also I met with heretofore; wherein, for that the business was not rightly understood, many disorders, vast expences, and considerable mischiefs have followed. There was heretofore an Emissary or Sluice made to drain the Waters, which from Rains, Springs, and Rivolets fall into a Lake; to the end, the shores adjoining on the Lake, should be free from the overflowing of the Waters; but because perhaps the enterprize was not well managed and carried on, it fell out, that the Fields adjacent to the said Chanel could not drain, but continued under water; to which disorders a present remedy hath been used, namely, in a time convenient to stop up the Sluice, by meanes of certain Floodgates kept on purpose for that end; and thus abating the Level of the Water in

in the Emissary, in the space of three or four dayes, the Fields have been haply drained. But on the other part, the proprietors bordering on the Lake opposed this, grievously complaining, that whilst the Floodgates are shut, and the course of the Water of the Sluice hindered, the Lake overflows the Lands adjacent, by means of the Rivers that fell into it, to their very great damage; and so continuing their suits, they got more of vexation than satisfaction. Now, being asked my opinion herein, I judged it requisite (since the point in controversie was about the rising and falling of the Lake) that the said abatement, when the Floodgates are open, and increase when they are shut should be exactly measured, and told them, that it might be easily done at a time when no extraordinary Waters fell into the Lake, neither of Rain, or otherwise; and the Lake was undisturbed by winds that might drive the Water to any side, by planting neer to an Islet, which is about the middle of the Lake, a thick post, on which should be made the marks of the Lakes rising and falling for two or three dayes. I would not, at that time, pawn, or resolutely declare, my judgment, in regard I might be, by divers accidents misled. But this I told them, that (by what I have demonstrated, and particularly that which I have said above touching the Lake of *Perugia*) I inclined greatly to think, that these risings and fallings would prove imperceptible, and inconsiderable; and therefore, that in case experience should make good my reason, it would be to no purpose for them to continue disputing and wrangling, which causeth, (according to the Proverb) *A great deal of cry, but produceth not much Wool.*

Lastly, it importing very much to know what a Rain continued for many dayes can do in raising these Lakes, I will here insert the Copy of a Letter, which I writ formerly to *Signior Galileo Galilei*, chief Philosopher to the Grand Duke of *Tuscany*, wherein I have delivered one of my conceits in this businesse, and it may be, by this Letter, I may, more strongly, confirm what I have said above.

Eccc **The**

*The Copy of a Letter to Signore GALILÆO
GALILÆI, Chief Philosopher to the most Serene
Great Duke of TUSCANY.*

Worthy and most Excellent SIR,

IN satisfaction of my promise, in my former Letters of representing unto you some of my Considerations made upon the Lake *Thrasimeno*, I say, That in times past, being in *Perugia*, where we held our General Convention, having understood that the Lake *Thrasimeno*, by the great drought of many Moneths was much abated, It came into my head, to go privately and see this novelty, both for my particular satisfaction, as also that might I be able to relate the whole to my Patrons, upon the certitude of my own sight of the place. And so being come to the Emissary of the Lake, I found that the Level of the Lakes surface was ebbed about five Roman Palmes of its wonted watermark, insomuch that it was lower than the transome of the mouth of the Emissary, by the length of ———— this described line, and therefore no Water issued out of the Lake, to the great prejudice of all the places and villages circumjacent, in regard that the Water which used to run from the said Lake turned 22 Mills, which not going, necessitated the inhabitants of those parts to go a dayes journey and more, to grinde upon the *Tiber*. Being returned to *Perugia*, there followed a Rain, not very great, but constant, and even, which lasted for the space of eight hours, or thereabouts; and it came into my thoughts to examine, being in *Perugia*, how much the Lake was increased and raised by this Rain, supposing (as it was probable enough) that the Rain had been universal over all the Lake; and like to that which fell in *Perugia*, and to this purpose I took a Glasse formed like a Cylinder, about a palme high, and half a palme broad; and having put in water sufficient to cover the bottome of the Glasse, I noted diligently the mark of the height of the Water in the Glasse, and afterwards exposed it to the open weather, to receive the Raine-water, which fell into it; and I let it stand for the space of an hour; and having observed that in that time the Water was risen in the Vessel the height of the following line——, I considered that if I had exposed to the same rain such other vessels equal to that, the Water would have risen in them all according to that measure: And thereupon concluded, that also in all
the

the whole extent of the Lake, it was necessary the Water should be raised in the space of an hour the same measure. Yet here I considered two difficulties that might disturb and alter such an effect, or at least render it inobservable, which afterwards well weighed, and resolved, left me (as I will tell you anon) in the conclusion the more confirmed; that the Lake ought to be increased in the space of eight hours, that the rain lasted eight times that measure. And whilst I again exposed the Glass to repeat the experiment, there came unto me an Ingenieur to talk with me touching certain affairs of our Monastery of *Perugia*, and discoursing with him, I shewed him the Glass out at my Chamber-window, exposed in a Court-yard; and communicated to him my fancy, relating unto him all that I had done. But I soon perceived that this brave fellow conceited me to be but of a dull brain, for he smiling said unto me; Sir, you deceive your self: I am of opinion that the Lake will not be increased by this rain, so much as the thicknesse of a * *Julio*. Hearing him pronounce this his opinion with freedom and confidence, I urged him to give me some reason for what he said, assuring him, that I would change my judgement, when I saw the strength of his Arguments: To which he answered, that he had been very conversant about the Lake, and was every day upon it, and was well assured that it was not at all increased. And importuning him further, that he would give me some reason for his so thinking, he proposed to my consideration the great drought passed, and that that same rain was nothing for the great parching: To which I answered, I believe Sir that the surface of the Lake, on which the rain had fallen was moistened; and therefore saw not how its drought, which was nothing at all, could have drunk up any part of the rain. For all this he persisting in his conceit, without yielding in the least to my allegation; he granted in the end (I believe in civility to me) that my reason was plausible and good, but that in practise it could not hold. At last to clear up all, I made one be called, and sent him to the mouth of the Emissary of the Lake, with order to bring me an exact account, how he found the water of the Lake, in respect of the Transome of the Sluice. Now here, Signore *Galilo*, I would not have you think that I had brought the matter in hand to concern me in my honour; but believe me (and there are witnesses of the same still living) that my messenger returning in the evening to *Perugia*, he brought me word, that the water of the Lake began to run through the Cave; and that it was risen almost a fingers breadth above the Transome: Insomuch, that adding this measure, to that of the lowness of the surface of the Lake, beneath the Transome before the rain,

* A Coyn of Pope
Julius worth six
pence.

it was manifest that the rising of the Lake caused by the rain, was to a hair those four fingers breadth that I had judged it to be. Two dayes after I had another bout with the Ingeneer, and related to him the whole business, to which he knew not what to answer.

Now the two difficulties which I thought of, able to impede my conclusion, were these following: First, I considered that it might be, that the Wind blowing from the side where the Sluice stood, to the Lake-ward; the mole and mass of the Water of the Lake might be driven to the contrary shore; on which the Water rising, it might be fallen at the mouth of the Emissary, and so the observation might be much obscured. But this difficulty wholly vanished by reason of the Aires great tranquillity; which it kept at that time, for no Wind was stirring on any side, neither whilst it rained, nor afterwards.

The second difficulty which put the rising in doubt, was, That having observed in *Florence*, and elsewhere, those Ponds into which the rain-water, falling from the house, is conveyed through the Common-shores: And that they are not thereby ever filled, but that they swallow all that abundance of water, that runs into them by those conveyances which serve them with water; insomuch that those conveyances which in time of drought maintain the Pond, when there comes new abundance of water into the Pond, they drink it up, and swallow it: A like effect might also fall out in the Lake, in which there being many veins (as it is very likely) that maintain and feed the Lake; these veins might imbibe the new addition of the Rain-water, and so by that means annull the rising; or else diminish it in such sort, as to render it inobservable. But this difficulty was easily resolved by considering my Treatise of the measure of Running-Waters; forasmuch as having demonstrated, that the abatement of a Lake beareth the reciprocal proportion to the velocity of the Emissary, which the measure of the Section of the Emissary of the Lake, hath to the measure of the surface of the Lake: making the calculation and account, though in gross; by supposing that its veins were sufficiently large, and that the velocity in them were notable in drinking up the water of the Lake; yet I found nevertheless, that many weeks and moneths would be spent in drinking up the new-come abundance of water by the rain, so that I rested sure, that the rising would ensue, as in effect it did.

And because many of accurate judgement, have again caused me to question this rising, setting before me, that the Earth being parched by the great drought, that had so long continued, it might be, that that Bank of Earth which environed the brink of the Lake, being dry, and imbibing great abundance of Water
from

from the increasing Lake, would not suffer it to increase in height: I say therefore, that if we would rightly consider this doubt here proposed, we should, in the very consideration of it, see it resolved; for, it being supposed that that list or border of Banks which was to be occupied by the increase of the Lake, be a Brace in breadth quite round the Lake, and that by reason of its dryness it sucks in water, and that by that means this proportion of water co-operates not in raising of the Lake: It is absolutely necessary on the other hand, that we consider, That the Circuit of the water of the Lake being thirty miles, as is commonly held, that is to say, Ninety thousand Braces of *Florence* in compass; and therefore admitting for true, that each Brace of this Bank drink two quarts of water, and that for the spreading it require three quarts more, we shall finde, that the whole aggregate of this portion of water, which is not employed in the raising of the Lake, will be four hundred and fifty thousand Quarts of water; and supposing that the Lake be sixty square miles, three thousand Braces long, we shall finde, that to disperse the water posselt by the Bank about the Lake, above the total surface of the Lake, it ought to be spread so thin, that one sole quart of water may over-spread ten thousand square Braces of surface: such a thinness, as must much exceed that of a leaf of beaten Gold, and also less than that skin of water which covers the Bubbles of it: and such would that be, which those men would have subtracted from the rising of the Lake: But again, in the space of a quarter of an hour at the beginning of the rain, all that Bank is soaked by the said rain, so that we need not for the moistning of it, employ a drop of that water which falleth into the Lake. Besides we have not brought to account that abundance of water which runs in time of rain into the Lake, from the steepness of the adjacent Hills and Mountains; which would be enough to supply all our occasions: So that, neither ought we for this reason to question our pretended rising. And this is what hath fallen in my way touching the consideration of the *Thrasimenean* Lake.

After which, perhaps somewhat rashly, wandering beyond my bounds, I proceeded to another contemplation, which I will relate to you, hoping that you will receive it, as collected with these cautions requisite in such like affairs; wherein we ought not too positively to affirm any thing of our own heads for certain, but ought to submit all to the sound and secure deliberation of the Holy Mother-Church, as I do this of mine, and all others; most ready to change my judgement, and conform my self alwaies to the deliberations of my Superiors. Continuing

ing therefore my above-said conceit about the rising of the water in the glass tried before, it came into my minde, that the forementioned rain having been very gentle; it might well be, that if there should have fallen a Rain fifty, an hundred, or a thousand times greater than this, and much more intense (which would insue as oft as those falling drops were four, five or ten times bigger than those of the above-mentioned rain, keeping the same number) in such a case its manifest, that in the space of an hour the Water would rise in our Glass, two, three, and perhaps more Yards or Braces; and consequently, if such a Raine should fall upon a Lake, that the said Lake would rise, according to the same rate: And likewise, if such a Rain were universall, over the whole Terrestriall Globe, it would necessarily, in the space of an hour, make a rising of two, or three braces round about the said Globe. And because we have from Sacred Records, that in the time of the Deluge, it rained fourty dayes and fourty nights; namely, for the space of 960 houres; its clear, that if the said Rain had been ten times bigger than ours at *Perugia*, the rising of the Waters above the Terrestrial Globe would reach and pass a mile higher than the tops of the Hills and Mountains that are upon the superficies of the Earth; and they also would concur to increase the rise. And therefore I conclude, that the rise of the Waters of the Deluge have a rational congruity with natural Discourses, of which I know very well that the eternal truths of the Divine leaves have no need; but however I think so clear an agreement is worthy of our consideration, which gives us occasion to adore and admire the greatnesse of God in his mighty Works, in that we are sometimes able, in some sort, to measure them by the short Standard of our Reason.

Many Lessons also may be deduced from the same Doctrine, which I passe by, for that every man of himself may easily know them, having once established this Maxime; That it is not possible to pronounce any thing, of a certainty, touching the quantity of Running Waters, by considering only the single vulgar measure of the Water without the velocity; and so on the contrary, he that computes only the velocity, without the measure, shall commit very great errors; for treating of the measure of Running Waters, it is necessary, the water being a body, in handling its quantity, to consider in it all the three dimensions of breadth, depth, and length: the two first dimensions are observed by all in the common manner, and ordinary way of measuring Running Waters; but the third dimension of length is omitted; and happily such an oversight is committed, by reason the length of Running

ning Water is reputed in some sense infinite, in that it never ceaseth to move away, and as infinite is judged incomprehensible; and such as that there is no exact knowledge to be had thereof; & so there comes to be no account made thereof; but if we should make strict reflection upon our consideration of the velocity of Water, we should find, that keeping account of the same, there is a reckoning also made of the length; forasmuch as whilst we say, the Water of such a Spring runs with the velocity of passing a thousand or two thousand paces an hour: this in substance is no other than if we had said, such a Fountain dischargeth in an hour a Water of a thousand or two thousand paces long. So that, albeit the total length of Running water be incomprehensible, as being infinite, yet nevertheless its rendered intelligible by parts in its velocity. And so much sufficeth to have hinted about this matter, hoping to impart on some other occasion other more accurate Observations in this affair.

LAUS DEO.



F f f f

The first of these is the...
the second is the...
the third is the...
the fourth is the...
the fifth is the...
the sixth is the...
the seventh is the...
the eighth is the...
the ninth is the...
the tenth is the...

1712 DEC



GEOMETRICAL
DEMONSTRATIONS
OF THE
MEASURE
OF
Running Waters.

BY
D. BENEDETTO CASTELLI,
Abbot of CASSINA, and Mathematician to
P. URBAN. VIII.

DEDICATED
To the most Illustrious, and most Excellent Prince
DON THADDEO BARBERINI,
PRINCE OF
PALESTRINA,
AND
GENERAL of the HOLY CHURCH.

LONDON,
Printed *Anno Domini*, MDCLXI.
Ffff 2

GEOMETRICAL
DEMONSTRATIONS
OF THE
MEASURE

Running Waters

D. BENEDETTO CASTELLI,
Abbot of CASTELL, and Mathematician to
P. ABBATE VNI

DEDICATED
TO THE MOST ILLUSTRIOUS PRINCE OF SALERNO
DON THADDEO BARBERINI
PRINCE OF

PALESTRINA

AND
GENERAL of the HOLY CHURCH

LONDON:
Printed by J. Streater, in Strand, near the Temple-Gate.
MDCCLXXII.

OF THE MENSURATION OF Running Waters.

SUPPOSITION I.

Let it be supposed, that the banks of the Rivers of which we speak be erected perpendicular to the plane of the upper superficies of the River.

SUPPOSITION II.

WE suppose that the plane of the bottome of the River, of which we speak is at right angles with the banks.

SUPPOSITION III.

IT is to be supposed, that we speak of Rivers, when they are at Ebbe, in that state of shallownesse, or at flowing in that state of deepnesse, and not in their transition from the ebbe to the flowing, or from the flowing to the ebbe.

Declaration of Termes.

FIRST.

IF a River shall be cut by a Plane at right angles to the surface of the water of the River, and to the banks of the River, that same dividing Plane we call the Section of the River; and this Section, by the Suppositions above, shall be a right angled Parallelogram.

SECOND.

WE call those Sections equally Swift, by which the water runs with equal velocity; and more swift and less swift that Section of another, by which the water runs with greater or less velocity.

A X

AXIOME I.

Sections equal, and equally swift, discharge equal quantities of Water in equal times.

AXIOME II.

Sections equally swift, and that discharge equal quantity of Water, in equal time, shall be equal.

AXIOME III.

Sections equal, and that discharge equal quantities of Water in equal times, shall be equally swift.

AXIOME IV.

When Sections are unequal, but equally swift, the quantity of the Water that passeth through the first Section, shall have the same proportion to the quantity that passeth through the Second, that the first Section hath to the second Section. Which is manifest, because the velocity being the same, the difference of the Water that passeth shall be according to the difference of the Sections.

AXIOME V.

If the Sections shall be equal, and of unequal velocity, the quantity of the Water that passeth through the first, shall have the same proportion to that which passeth through the second, that the velocity of the first Section, shall have to the velocity of the second Section. Which also is manifest, because the Sections being equal, the difference of the Water which passeth, dependeth on the velocity.

PETITION.

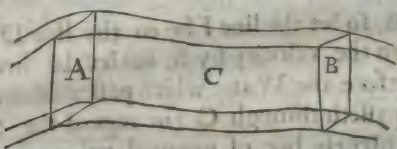
A Section of a River being given, we may suppose another equal to the given, of different breadth, heighth, and velocity.

PRO-

PROPOSITION I.

The Sections of the same River discharge equal quantities of Water in equal times, although the Sections themselves be unequal.

Let the two Sections be A and B, in the River C, running from A, towards B; I say, that they discharge equal quantity of Water in equal times; for if greater quantity of Water should pass through A, than passeth through B, it would



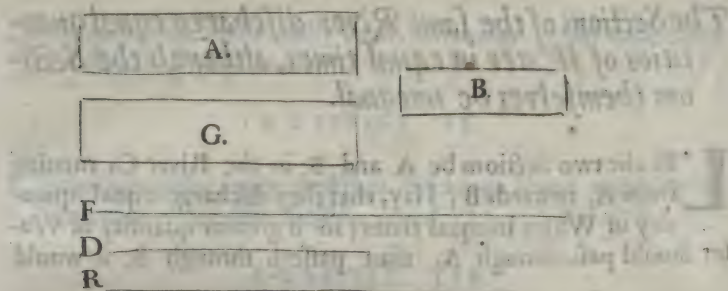
follow that the Water in the intermediate space of the River C, would increase continually, which is manifestly false; but if more Water should issue through the Section B, than entereth at the Section A, the Water in the intermediate space C, would grow continually less, and alwaies ebb, which is likewise false; therefore the quantity of Water that passeth through the Section B, is equal to the quantity of Water which passeth through the Section A, and therefore the Sections of the same River discharge, &c. Which was to be demonstrated.

PROPOSITION II.

In two Sections of Rivers, the quantity of the Water which passeth by one Section, is to that which passeth by the second, in a Proportion compounded of the proportions of the first Section to the second, and of the velocitie through the first, to the velocitie of the second.

Let A, and B be two Sections of a River; I say, that the quantity of Water which passeth through A, is to that which passeth through B, in a proportion compounded of the proportions of the first Section A; to the Section B; and of the velocity through A, to the velocity through B: Let a Section be supposed

supposed equal to the Section A, in magnitude; but of velocity equal to the Section B, and let it be G; and as the Section A is



to the Section B, so let the line F be to the line D; and as the velocity A, is to the velocity by B, so let the line D be to the line R: Therefore the Water which passeth thorow A, shall be to that which passeth through G (in regard the Sections A and G are of equal bigness, but of unequal velocity) as the velocity through A, to the velocity through G; But as the velocity through A, is to the velocity through G, so is the velocity through A, to the velocity through B; namely, as the line D, to the line R: therefore the quantity of the Water which passe the through A, shall be to the quantity which passeth through G, as the line D is to the line R; but the quantity which passeth through G, is to that which passeth through B, (in regard the Sections G, and B, are equally swift) as the Section G to the Section B; that is, as the Section A, to the Section B; that is, as the line F, to the line D: Therefore by the equal and perturbed proportionality, the quantity of the Water which passeth through A, hath the same proportion to that which passeth through B, that the line F hath to the line R; but F to R, hath a proportion compounded of the proportions of F to D, and of D to R; that is, of the Section A to the Section B; and of the velocity through A, to the velocity through B: Therefore also the quantity of Water which passeth through the Section A, shall have a proportion to that which passeth through the Section B, compounded of the proportions of the Section A, to the Section B, and of the velocity through A, to the velocity through B: And therefore in two Sections of Rivers, the quantity of Water which passeth by the first, &c. which was to be demonstrated,

COROLLARIE.

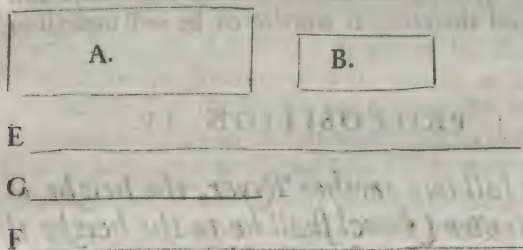
THe same followeth, though the quantity of the Water which passeth through the Section A, be equal to the quantity of Water which passeth through the Section B, as is manifest by the same demonstration.

PROPO.

PROPOSITION III.

In two Sections unequal, through which pass equal quantities of Water in equal times, the Sections have to one another, reciprocal proportion to their velocitie.

Let the two unequal Sections, by which pass equal quantities of Water in equal times be A, the greater; and B, the lesser:
I say, that the Section A, shall have the same Proportion to the Section B, that reciprocally the velocity through B, hath to the velocity through A; for supposing that as the Water, that passeth through A, is to that which passeth through B, so is the



line E to the line F: therefore the quantity of water which passeth through A, being equal to that which passeth through B, the line E shall also be equal to the line F: Supposing moreover, That as the Section A, is to the Section B, so is the line F, to the line G; and because the quantity of water which passeth through the Section A, is to that which passeth through the Section B, in a proportion composed of the proportions of the Section A, to the Section B, and of the velocity through A, to the velocity through B; therefore the line E, shall be the line to F, in a proportion compounded of the same proportions; namely, of the proportion of the Section A, to the Section B, and of the velocity through A, to the velocity through B; but the line E, hath to the line G, the proportion of the Section A, to the Section B, therefore the proportion remaining of the line C, to the line F, shall be the proportion of the velocity through A, to the velocity through B; therefore also the line G, shall be to the line E, as the velocity by A, to the velocity by B: And conversly, the velocity through B, shall be to the velocity through A, as the line E, to the line G; that is to say, as the Section A, to the Section B, and therefore in two Sections, &c. which was to be demonstrated.

G g g g

C O R O L.

COROLLARIE.

Hence it is manifest, that Sections of the same River (which are no other than the vulgar measures of the River) have betwixt themselves reciprocal proportions to their velocities; for in the first Proposition we have demonstrated that the Sections of the same River, discharge equal quantities of Water in equal times; therefore, by what hath now been demonstrated the Sections of the same River shall have reciprocal proportion to their velocities; And therefore the same running water changeth measure, when it changeth velocity; namely, increaseth the measure, when it decreaseth the velocity, and decreaseth the measure, when it increaseth the velocity.

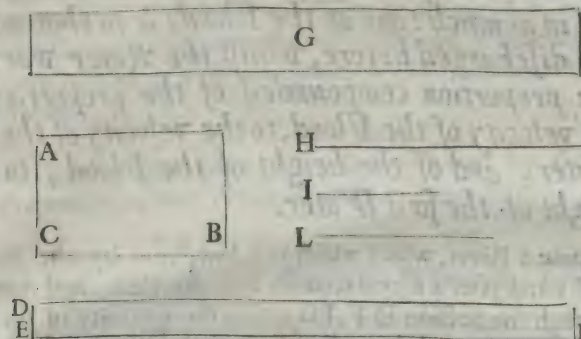
On which principally depends all that which hath been said above in the *Discourse*, and observed in the *Corollaries* and *Appendixes*; and therefore is worthy to be well understood and heeded.

PROPOSITION IV.

If a River fall into another River, the height of the first in its own Chanel shall be to the height that it shall make in the second Chanel, in a proportion compounded of the proportions of the breadth of the Chanel of the second, to the breadth of the Chanel of the first, and of the velocitie acquired in the Chanel of the second, to that which it had in its proper and first Chanel.

Let the River A B, whose height is A C, and breadth C B, that is, whose Section is A C B; let it enter, I say, into another River as broad as the line E F, and let it therein make the rise or height D E, that is to say, let it have its Section in the River whereinto it falls D E F; I say, that the height A C hath to the height D E the proportion compounded of the proportions of the breadth E F, to the breadth C B, and of the velocity through D F, to the velocity through A B. Let us suppose the Section C, equal in velocity to the Section A B; and in breadth equal to E F, which carrieth a quantity of Water equal to that which the Section A B carrieth, in equal times, and consequently, equal to that which D F carrieth. Moreover, as the breadth E F is to the breadth C B, so let the line H be to the

the line I; and as the velocity of D F is to the velocity of A B, so let the line I be to the line L; because therefore the two Sections A B and G are equally swift, and discharge equal quantity of Water in equal times, they shall be equal Sections; and



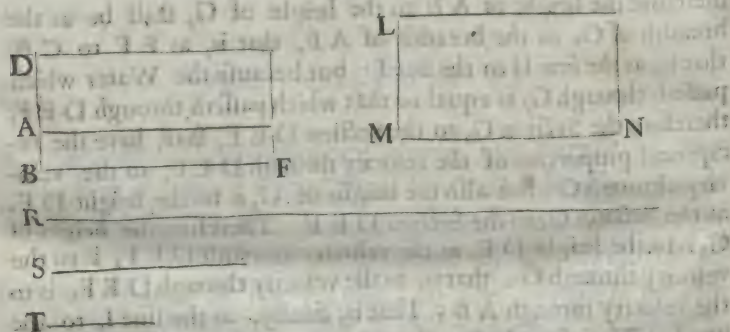
therefore the height of A B to the height of G, shall be as the breadth of G, to the breadth of A B, that is, as E F to C B, that is, as the line H to the line I: but because the Water which passeth through G, is equal to that which passeth through D E F, therefore the Section G, to the Section D E F, shall have the reciprocal proportion of the velocity through D E F, to the velocity through G; but also the height of G, is to the height D E, as the Section G, to the Section D E F: Therefore the height of G, is to the height D E, as the velocity through D E F, is to the velocity through G; that is, as the velocity through D E F, is to the velocity through A B; That is, finally, as the line I, to the line L; Therefore, by equal proportion, the height of A B, that is, A C, shall be to the height D E; as H to L; that is, compounded of the proportions of the breadth E F, to the breadth C B, and of the velocity through D F, to the velocity through A B: So that if a River fall into another River, &c. which was to be demonstrated.

G g g g 2 PROPO.

PROPOSITION V.

If a River discharge a certain quantitie of Water in a certain time; and after that there come into it a Flood, the quantity of Water which is discharged in as much time at the Flood, is to that which was discharged before, whilst the River was low, in a proportion compounded of the proportions of the velocity of the Flood, to the velocity of the first Water, and of the height of the Flood, to the height of the first Water.

Suppose a River, which whilst it is low, runs by the Section A F; and after a Flood cometh into the same, and runneth through the Section D F, I say, that the quantity of the Water which is discharged through D F, is to that which is discharged



through A F, in a proportion compounded of the proportions of the velocity through D F, to the velocity through A F, and of the height D B, to the height A B; As the velocity through D F is to the velocity through A F, so let the line R, to the line S; and as the height D B is to the height A B, so let the line S, to the line T; and let us suppose a Section L M N, equal to D F in height and breadth; that is L M equal to D B, and M N equal to B F; but let it be in velocity equal to the Section A F, therefore the quantity of Water which runneth through D F, shall be to that which runneth through L N, as the velocity through D F, is to the velocity through L N, that is, to the velocity through A F; and the line R being to the line S, as the velocity through D F, to the velocity through A F; therefore the quantity which runneth through D F, to that which runneth through L N, shall have the proportion of R to S; but the quantity which runneth through L N, to that which runneth through A F, (the Sections being

being equally swift) shall be in proportion as the Section LN , to the Section AF ; that is, as DB , to AB ; that is as the line S , to the line T : Therefore by equal proportion, the quantity of the water which runneth through DF , shall be in proportion to that which runneth through AF , as R is to T ; that is, compounded of the proportions of the height DB , to the height AB , and of the velocity through DF , to the velocity through AF ; and therefore if a River discharge a certain quantity, &c. which was to be demonstrated.

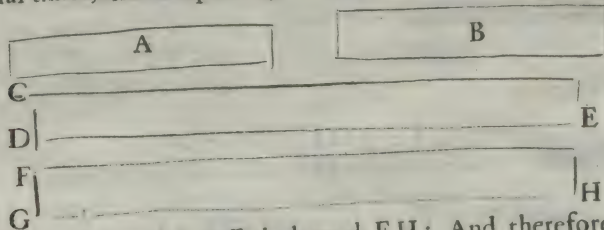
ANNOTATION.

The same might have been demonstrated by the second Proposition above demonstrated, as is manifest.

PROPOSITION VI.

If two equal streams of the same Torrent, fall into a River at divers times, the heights made in the River by the Torrent, shall have between themselves the reciprocal proportion of the velocities acquired in the River.

Let A and B , be two equal streams of the same Torrent, which falling into a River at divers times, make the heights CD , and FG ; that is the stream A , maketh the height CD , and the stream B , maketh the height FG ; that is, Let their Sections in the River, into which they are fallen, be CE , and FH ; I say, that the height CD , shall be to the height FG , in reciprocal proportion, as the velocity through FH , to the velocity through CE ; for the quantity of water which passeth through A , being equal to the quantity which passeth through B , in equal times; also the quantity which passeth through CE , shall



be equal to that which passeth through FH : And therefore the proportion that the Section CE , hath to the Section FH , shall be the same that the velocity through FH , hath to the velocity through CE ; But the Section CE , is to the Section FH , as CD , to FG , by reason they are of the same breadth: Therefore CD , shall be to FG , in reciprocal proportion, as the velocity through FH , is to the velocity through CE , and therefore if two equal streams of the same Torrent, &c. which was to be demonstrated.

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...
...the ... of the ...

OF THE MENSURATION OF Running Waters.

Lib. II.



Having, in the close of my Treatise of the Mensuration of Running Waters promised to declare upon another occasion other particulars more obscure, and of very great concern upon the same argument: I now do perform my promise on the occasion that I had the past year 1641. to propound my thoughts touching the state of the Lake of Venice, a business certainly most important, as being the concernment of that most noble and most admirable City; and indeed of all Italy, yea of all Europe, Asia, & Africa; & one may truly say of all the whole World. And being to proceed according to the method necessary in Sciences, I will propose, in the first place certain Definitions of those Terms whereof we are to make use in our Discourse: and then, laying down certain Principles we will demonstrate some Problemes and Theoremes necessary for the understanding of those things which we are to deliver; and moreover, recounting sundry cases that have happened, we will prove by practice, of what utility this contemplation of the Measure of Running Waters is in the more important affairs both Publique and Private.

DEFINITION I.

TWO Rivers are said to move with equal velocity, when in equal times they passe spaces of equal length.

DEFINITION II.

RIVERS are said to move with like velocity, when their proportional parts do move alike, that is, the upper parts alike to the upper, and the lower to the lower; so that if the upper part of one River shall be more swift than the upper part of another; then also the lower part of the former shall be more swift than the part correspondent to it in the second, proportionally.

DEFI-

DEFINITION III.

TO measure a River, or running Water, is in our sense to finde out how many determinate measures, or weights of Water in a given time passeth through the River, or Channel of the Water that is to be measured.

DEFINITION IV.

IF a Machine be made either of Brick, or of Stone, or of Wood, so composed that two sides of the said Machine be placed at right angles upon the ends of a third side, that is supposed to be placed in the bottom of a River, parallel to the Horizon, in such a manner, that all the water which runneth through the said River, passeth thorow the said Machine: And if all the water coming to be diverted that runneth through the said River, the upper superficies of that third side placed in the bottom do remain uncovered and dry, and that the dead water be not above it: This same Machine shall be called by us *REGULATOR*: And that third side of the Machine which standeth Horizontally is called the bottom of the Regulator; and the other two sides, are called the banks of the Regulator; as is seen in this first Figure: *A B C D*, shall be the Regulator; *B C* the bottom; and the other two sides *A B*, and *C D* are its banks.



* Or Sluice.

DEFINITION V.

BY the quick height, we mean the Perpendicular from the upper superficies of the River, unto the upper superficies of the bottom of the Regulator; as in the foregoing Figure the line. *G H*.

DEFINITION VI.

IF the water of a River be supposed to be marked by three sides of a Regulator, that Rightangled Parallelogram comprehended between the banks of the Regulator, and the bottom, and the superficies of the Water is called a Section of the River.

ANNO TA.

ANNOTATION.

Here it is to be noted, that the River it self may have fundry and divers heights, in several parts of its Chânel, by reason of the various velocities of the water, and its measures; as hath been demonstrated in the first book.

SUPPOSITION I.

IT is supposed, that the Rivers equal in breadth, and quick height, that have the same inclination of bed or bottom, ought also to have equal velocities, the accidental impediments being removed that are dispersed throughout the course of the water, and abstracting also from the external windes, which may velocitate, and retard the course of the water of the River.

SUPPOSITION II.

Let us suppose also, that if there be two Rivers that are in their beds of equal length, and of the same inclination, but of quick heights unequal, they ought to move with like velocity, according to the sense explained in the second definition.

SUPPOSITION III.

Because it will often be requisite to measure the time exactly in the following Problems, we take that to be an excellent way to measure the time, which was shewed me many years since by *Signore Galileo Galilei*, which is as followeth.

A string is to be taken three Roman feet long, to the end of which a Bullet of Lead is to be hanged, of about two or three ounces; and holding it by the other end, the Plummer is to be removed from its perpendicularity a Palm, more or less, and then let go, which will make many swings to and again, passing and repassing the Perpendicular, before that it stay in the same: Now it being required to measure the time that is spent in any whatsoever operation, those vibrations are to be numbred, that are made whilst the work lasteth; and they shall be so many second minutes of an hour, if so be, that the string be three Roman feet long, but in shorter strings, the vibrations are more frequent, and in longer, less frequent; and all this still followeth, whether the Plummer be little or much removed from its Perpendicularity, or whether the weight of the Lead be greater or lesser.

These things being pre-supposed, we will lay down some familiar

H h h h

miliar

miliar Problems, from which we shall pass to the Notions and questions more subtil and curious; which will also prove profitable, and not to be sleighted in this business of Waters.

PROPOSITION I. PROBLEME I.

A Chanel of Running-Water being given, the breadth of which passing through a Regulator, is three Palms; and the height one Palm, little more or less, to measure what water passeth through the Regulator in a time given.

First, we are to dam up the Chanel; so that there pass not any water below the Dam; then we must place in the side of the Chanel, in the parts above the Regulator three, or four, or five Bent-pipes, or Syphons; according to the quantity of the water that runneth along the Chanel; in such sort, as that they may drink up, or draw out of the Chanel all the water that the Chanel beareth (and then shall we know that the Syphons drink up all the water, when we see that the water at the Dam doth neither rise higher, nor abate, but alwaies keepeth in the same Level.) These things being prepared, taking the Instrument to measure the time, we will examine the quantity of the water that issueth by one of those Syphons in the space of twenty vibrations, and the like will we do one by one with the other Syphons; and then collecting the whole summe, we will say, that so much is the water that passeth and runneth thorow the Regulator or Chanel (the Dam being taken away) in the space of twenty second minutes of an hour; and calculating, we may easily reduce it to hours, dayes, months, and years: And it hath fallen to my turn to measure this way the waters of Mills and Fountains, and I have been well assured of its exactness, by often repeating the same work.

CONSIDERATION.

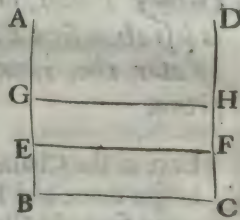
And this method must be made use of in measuring the waters, that we are to bring into Conduits, and carry into Cities and Castles, for Fountains; and that we may be able afterwards to divide and share them to particular persons justly; which will prevent infinite suits and controversies that every day happen in these matters.

PROPO-

PROPOSITION II. THEOREM I.

If a River moving with such a certain velocity through its Regulator, shall have a given quick height, and afterwards by new water shall increase to be double, it shall also increase double in velocity.

Let the quick height of a River in the Regulator $ABCD$, be the perpendicular FB , and afterwards, by new water that is added to the River, let the water be supposed to be raised to G , so that GB may be double to EB . I say, that all the water GC shall be double in velocity to that of EC : For the water GF , having for its bed the bottom EF , equally inclined as the bed BC , and its quick height GE being equal to the quick height EC , and having the same breadth BC , it shall have of it self a velocity equal to the velocity of the first water EC : but because, besides its own motion, which is imparted to it by the motion of the water EC , it hath also over and above its own motion, the motion of EC . And because the two waters GC , and EC , are alike in velocity, by the third Supposition; therefore the whole water GC shall be double in velocity to the water EC ; which was that which we were to demonstrate.



This demonstration is not here inserted, as perfect, the Author having by several letters to his friends confessed himself unsatisfied therewith; and that he intended not to publish the Theorem without a more solid demonstration, which he was in hope to light upon. But being overtaken by Death, he could not give the finishing touch either to this, or to the rest of the second Book. In consideration of which, it seemed good to the Publisher of the same, rather to omit it, than to do any thing contrary to the mind of the Author. And this he hints, by way of advertisement, to those that have Manuscript Copies of this Book, with the said demonstration. For this time let the Reader content himself with the knowledge of so ingenious and profitable a Conclusion; of the truth of which he may, with small expence and much pleasure, be assured by means of the experiment to be made in the same manner; with that which is laid down in the second Corollary of

H h h h 2

the fourth Theorem of this, with its Table, and the use thereof annexed.

COROLLARIE.

Hence it followeth, that when a River increaseth in quick height by the addition of new water, it also increaseth in velocity; so that the velocity hath the same proportion to the velocity that the quick height hath to the quick height; as may be demonstrated in the same manner.

PROPOS. III. PROBLEME II.

A Chancel of Water being given whose breadth exceeds not twenty Palms, or thereabouts, and whose quick height is less than five Palms, to measure the quantity of the Water that runneth thorow the Chancel in a time given.

Place in the Chancel a Regulator; and observe the quick height in the said Regulator; then let the water be turned away from the Chancel by a Chancellet of three or four Palms in breadth, or thereabouts. And that being done, measure the quantity of the water which passeth thorow the said Chancellet, as hath been taught in the second Proposition; and at the same time observe exactly how much the quick height shall be abated in the greater Chancel, by means of the diversion of the Chancellet; and all these particulars being performed, multiply the quick height of the greater Chancel into it self, and likewise multiply into it self the lesser height of the said bigger Chancel, and the lesser square being taken, from the greater, the remainder shall have the same proportion to the whole greater square, as the water of the Chancellet diverted, hath to the water of the bigger Chancel. And because the water of the Chancellet is known by the Method laid down in the first Theorem, and the terms of the Theorem being also known, the quantity of the water which runneth thorow the bigger Chancel, shall be also known by the Golden Rule, which was that that was desired to be known. We will explain the whole business by an example.

Let a Chancel be, for example, 15 Palms broad, its quick height before its diversion by the Chancellet shall be supposed to be 24 inches; but after the diversion, let the quick height of the Chancel be onely 22 inches. Therefore the greater height to the lesser, is as the number 11. to 12. But the square of 11. is 121, and the square of 12. is 144, the difference between the said lesser square

square and the greater is 23. Therefore the diverted water, is to the whole water, as 23. to 144: which is well near as 1 to 6.25: and that is the proportion that the quantity of the water which runneth through the Chanellet shall have, to all the water that runneth thorow the great Chanel. Now if we should finde by the Rule mentioned above in the first Proposition, that the quantity of the water that runneth through the Chanellet, is v. g. an hundred Barrels, in the space of 15 second minutes of an hour, it is manifest, that the water which runneth through the great Chanel in the said time of 35 min. sec. shall be about 600 Barrels.

The same operation performed another way.

And because very often in applying the Theory to Practice it happeneth, that all the necessary particulars in the Theory cannot so easily be put in execution; therefore we will here add another way of performing the same Problem, if it should chance to happen that the Chanellet could not commodiously be diverted from the great Chanel, but that it were easier for the water of another smaller Chanel, to be brought into the greater Chanel; which water of the smaller Chanel might be easily measured, as hath been shewen in the first Probleme; or in case that there did fall into a greater Chanel, a lesser Chanel that might be diverted and measured. Therefore I say in the first case, If we would measure the quantity of the water that runneth in a certain time thorow the greater Chanel, into which another lesser Chanel that is measurable may be brought, we must first exactly measure the Chanellet, and then observe the quick height of the greater Chanel, before the introduction of the lesser; and having brought in the said Chanellet, we must again find the proportion that the water of the Chanellet hath to all the water of the great Chanel; for these terms of the proportion being known, as also the quantity of the water of the Chanellet, we shall also come to know the quantity of the water that runneth thorow the great Chanel. It is likewise manifest, that we shall obtain our intent, if the case were that there entered into the great Chanel, another lesser Chanel that was measurable, and that might be diverted.

CONSIDERATION.

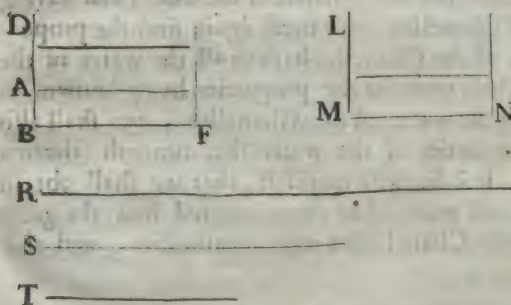
IT would be necessary to make use of this Doctrine in the distribution of the waters that are employ'd to overflow the fields, as is used in the Brescian, Cremonese, Bergamase, Lodigian, Milanese,

these territories, and many other places, where very great suits and differences arise, which not being to be determined with intelligible reasons, come oftentimes to be decided, by force of armes; and instead of flowing their Grounds with Waters, they cruelly flow them with the shedding of humane blood, impiously inverting the course of Peace and Justice, sowing such disorders and feuds, as that they are sometimes accompanied with the ruine of whole Cities, or else unprofitably charge them with vain, and sometimes prejudicial expences.

PROPOS. IV. THEOR. II.

If a River increase in quick height, the quantitie of Water which the River dischargeth after the increase, hath the Proportion compounded of the Proportions of the Quick height to the Quick height, and of the velocity to the velocity.

Let there be a River, which whilst it is low, runneth thorow the Regulator D F, with the Quick height A B, and afterwards let a Flood come; and then let it run with the height D B. I say, that the quantity of the Water that is discharged through D F, to that which dischargeth through A F, hath the proportion compounded of the proportions of the velocity through D F to the velocity through A F, and of the height D B to the height A B. As the velocity through D F is to the velocity through A F, so let the line R be to the line S; and as the height D B is to the height A B; so let the line S be to the



line T. And let a Section be supposed L M N equal to the Section D F in height and length, but let it be in velocity equal to the Section A F. Therefore the quantity of the Water that runneth through D F to that which runneth through L N, shall be

as

as the velocity through DF , to the velocity of LN , that is, to the velocity through LN , that is, to the velocity through AF . therefore the quantity of Water which runneth through DF , to that which passeth through LN , shall have the proportion that R hath to S ; but the quantity of the Water that runneth through LN , to that which runneth through AF ; (the Sections being equally swift) shall have the proportion that the Section LN hath to the Section AF , that is, that the height BD hath to the height BA , that is, that S hath to T . Therefore, by equal proportion, the quantity of the Water which runneth by DF , to that which runneth by AF , shall have the proportion of R to T , that is, shall be compounded of the proportions of the height DB , to the height AB ; and of the velocity through DF , to the velocity through AF . And therefore if a River increase in quick height, the quantity of the Water that runneth after the increase, to that which runneth before the increase, hath the proportion compounded, &c. Which was to be demonstrated.

COROLLARIE I.

Hence it followeth, that we having shewn, that the quantity of the Water which runneth, whilst the River is high, to that which ran, whilst it was low, hath the proportion compounded of the velocity to the velocity, and of the height to the height. And it having been demonstrated, that the velocity to the velocity is as the height to the height; it followeth, I say, that the quantity of the Water that runneth, whilst the River is high, to that which runneth, whilst it is low, hath duplicate proportion of the height to the height, that is, the proportion that the squares of the heights have.

COROLLARIE II.

Vpon which things dependeth the reason of that which I have said, in my second Consideration, that if by the diversion of $\frac{1}{3}$ of the Water that entereth by the Rivers into the Moor or Fen, the Water be abated such a measure, that same shall be only one third of its whole height; but moreover diverting the $\frac{1}{3}$, it shall abate two other thirds, a most principal point; and such, that its not having been well understood, hath caused very great disorders, and there would now, more than ever, follow extream damage, if one should put in execution the diversion of the *Sile* and other Rivers; and it is manifest, that in the same manner, wherewith it hath been demonstrated, that the quantity of the Water increasing quadruple, the height would increase *only* double

Double, and the quantity increasing nonuple, the height increaseth triple; so that, by adding to units all the odde numbers, according to their Series, the heights increase according to the natural progression of all the numbers, from units. As for example, there passing thorow a Regulator such a certain quantity of Water in one time; adding three of those measures, the quick height is two of those parts, which at first was one; and continuing to adde five of those said measures, the height is three of those parts which at first were one; and thus adding seven, and then nine, and then 11. and then 13, &c. the heights shall be 4. then 5; then 6. then 7, &c. And for the greater facility of the Work, we have described the following Table, of which we will declare the use: The Table is divided into three Series or Progressions of Numbers: the first Series containeth all the Numbers in the Natural Progression, beginning at a Unit, and is called the Series of the Heights; the second containeth all the odde numbers, beginning at an unit, and is called the Series of the Additions: the third containeth all the square numbers, beginning at an unit, and is called the Series of Quantity.

Heights.	1	1	2	3	4	5	6	7	8	9	10	11
Additions.	1	1	3	5	7	9	11	13	15	17	19	21
Quantities.	1	1	4	9	16	25	36	49	64	81	100	121

The use of the afore-mentioned Table.

First, if we suppose the whole quick height of a River of Running Water to be divided into any number of equal parts, at pleasure, and would abate the same one fift, by means of a division; let there be found in the Table in the Series of heights the number 5. the denominator of the part which the River is to abate, and take the number that is immediately under it in the row of Additions, which is 9. which let be substracted from the number 25. placed underneath the same in the row of Quantities, the remainder 16. signifieth that of the 25. parts of Water that ran in the River, whilst it was 5 measures high, there do onely run 16. parts; so that to make it abate, it is necessary to take $\frac{9}{25}$ from the Water that the whole River did carry; so that with substracting somewhat more than one third of the Water of the River, it is abated but only one fift.

2. And thus, in the second place, if on the contrary, one would know how much water is to be added to the said River to make it increase one fift more in height, so as that it may run in the Regulator

Regulator 6. of those parts high ; of which it ran before but 5. let 6 be found in the row of heights, and let the number 11. standing under the same be taken and added to the number 25. that is placed under the number 9. in the Additions, and 5. in the heights, and you shall have 36. which is the quantity of the water that runneth with the height of the River, when it is high 6 of those parts, whereof it was before but 5.

3. But if it should be desired, to know how much water it is requisite to add to make the River rise so, as that it may run in height 8. of those parts of which before it ran but 5 ; one ought to take the sum of the number of the Series of Additions standing under 8. 7. and 6, which are 15. 13. and 11. that is, 39. and this shall be the summe that must be added to 25 : So that to make the River to run 8. of those parts in height, of which it before did run 5, it will be necessary to add 39. of those parts, of which the River before was 25.

4. Likewise the same Table giveth the quantity of water that runneth from time to time through a River, that increaseth by the addition of new water to the same in one of its heights, the quantity of its water be known. As for example: If we knew that the River in one minute of an hour dischargeth 2500. of those measures of water, and runneth in height 5. parts in the Regulator, and afterwards should see that it runneth 8 Palms high, finding in the row of quantity the number placed under 8. which is 64. we would say that the River heightned, carrieth of water 64. of those parts whereof it carried before but 25 ; and because before it carried 2500. measures, by the Golden Rule we will say, that the River carrieth 6400. of those measures, of which before it carried 2500.

In this progress of Nature, is one thing really curious, and that at first sight seemeth to be somewhat Paradoxal ; that we proceeding ordinately in the diversions and additions, with additions and diversions so unequal, the abatings do notwithstanding alwaies prove equal, and so do the risings : And who would ever think that a River in height, v. g. 10. Palms, running and carrying an hundred measures in a minute of an hour, is to abate but one Palm, onely by the diversion of 19. of those measures ; and then again, that the buisiness cometh to that pass, that it abateth likewise a Palm by the diversion of three onely of those measures, nay, by the diversion of but one measure ? and yet it is most certain : And this truth meets with so manifest proofs in experience, that it is very admirable ! And for the full satisfaction of those, who not being able to comprehend subtil demonstrations, desire to be clearly inform'd by the matters of fact, and to see with their bobily eyes, and touch with their hands, what their understanding and reason cannot reach unto : I will hear add another very easie way to reduce all to an experiment, the

Iiii

which

which may be made in little, in great, or in very great; of which I make use frequently, to the admiration of such as see it.

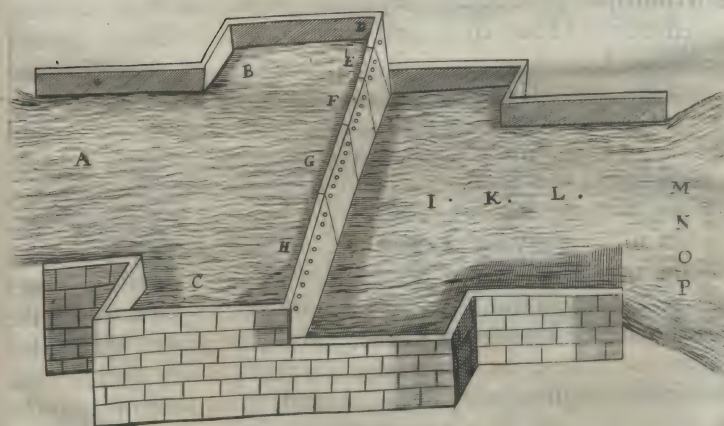
I prepared an hundred Syphons, or, if you will, bowed Pipes, all equal; and placed them at the brim of a Vessel, wherein the water is kept at one and the same level (whether all the Syphons work, or but a certain number of them) the mouths by which the water issueth being all placed in the same level, parallel to the Horizon; but lower in level than the water in the Vessel; and gathered all the water falling from the Syphons into another Vessel standing lower than the former, I made it to run away thorow a Chanel, in such manner inclined, that wanting water from the Syphons, the said Chanel remained quite dry.

And this done, I measured the quick height of the Chanel with care, and afterwards divided it exactly into 10 equal parts, and causing 19. of those Syphons to be taken away, so that the Chanel did not run water, save onely with 81 of those Syphons, I again observed the quick height of the water in the same site observed before, and found that its height was diminished precisely the tenth part of all its first height; and thus continuing to take away 17. other Syphons, the height was likewise diminished $\frac{1}{10}$ of all its first quick height; and trying to take away 15. Syphons, then 13, then 11, then 9, then 7, then 5, and then 3. alwaies in these diversions, made in order as hath been said, there ensued still an abatement of $\frac{1}{10}$ of the whole height.

And here was one thing worthy of observation, that the water encreasing in [or through] the Chanel, its quick height was different in different sites of the Chanel, that is still lesser, the more one approached to the Out-let; notwithstanding which the abatement followed in all places proportionably, that is in all its sites the first part of the height of that site diminished: And moreover the water issued from the Chanel, and dilated into a broader course, from which likewise having divers Out-lets and Mouths; yet nevertheless in that breadth also the quick heights successively varied and altered in the same proportions. Nor did I here desist my observation, but the water being diminished, that issued from the Syphons, and there being but one of them left that discharged water; I observed the quick height that it made in the above-said sites, (the which was likewise $\frac{1}{10}$ of all the first height) there being added to the water of that Syphon, the water of three other Syphons; so that all the water was of 4 Syphons, and consequently quadruple to the first Syphon; but the quick height was onely double, and adding five Syphons, the quick height became triple, and with adding seven Syphons, the height increased quadruple; and so by adding of 9. it increased quintuple, and by adding of 11. it increased sextuple, and by adding

ding of 13. it increased septuple, and by adding of 15. octuple, and by adding of 17. nonuple, and lastly by adding 19. Syphons; so that all the water was centuple to the water of one Syphon, yet nevertheless the quick height of all this water was onely decuple to the first height conjoynd by the water that issued from one onely Syphon.

For the more clear understanding of all which, I have made the following Figure; in which we have the mouth A, that maintaineth the water of the Vessel B C in the same level; though it continually run; to the brim of the Vessel are put 25. Syphons (and there may be many more) divided into 5 Classes, D E F G H, and the first D, are of one onely Syphon; the second E, of three Syphons; the third F, of five; the fourth G, of 7; the fifth H, of 9; and one may suppose the sixth of 11, the seventh of 13 Syphons, and so of the other Classes, all containing in consequent odd numbers successively (we are content to represent in the Figure no more but the five forenamed Classes to avoid confusion) the gathered water D E F G H, which runneth thorow the Chanel I K L, and falleth into the out-let M N O P; and so much sufficeth for the explanation of this experiment.



PROPOS. V. PROB. III.

Any River of any bigness, if being given to examine the quantity of the Water that runneth thorow the River in a time assigned.

BY what we have said already in the two preceding Problems, we may also resolve this that we have now before us; and it is done, by diverting in the first place from the great River a good big measurable Chanel, as is taught in the second Probleme, and observing the abatement of the River, caused by the diversion of the Chanel; and finding the proportion that the Water of the Chanel hath to that of the River, then let the Water of the Chanel be measured by the second Probleme, and work as above, and you shall have your desire.

CONSIDERATION. I.

ANd although it seemeth as if it might prove difficult, and almost impossible to make use of the Regulator number, if one be about to measure the water of some great River, and consequently would be impossible, or at least very difficult to reduce the Theory of the first Probleme into practice: Yet nevertheless, I could say that such great conceits of measuring the water of a great River, are not to come into the minds of any but great Personages, and potent Princes; of whom it is expected for their extraordinary concerns, that they will make these kinde of enquiries; as if here in *Italy* it should be of the Rivers *Tyber*, *Velino*, *Chiana*, *Arno*, *Serchio*, *Adice*, in which it seemeth really difficult to apply the Regulator, to finde exactly the quick height of the River: But because in such like cases sometimes it would turn to account to be at some charge, to come to the exact and true knowledge of the quantity of water which that River carrieth, by knowledge whereof, other greater disbursements might afterwards be avoided, that would oft times be made in vain; and prevent the disgusts, which sometimes happen amongst Princes: Upon this ground I think it will be well to shew also the way how to make use of the Regulator in these great Rivers; in which if we will but open our eyes, we shall meet with good ones, and those made without great cost or labour, which will serve our turn.

For upon such like Rivers there are Wears, or Lockes made,

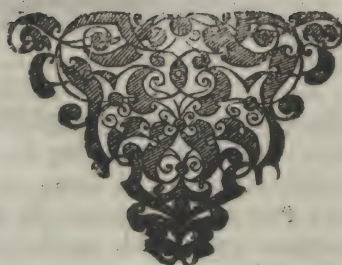
to cause the Waters to rise, and to turn them for the service of Mills, or the like. Now in these Cases it is sufficient, that one erect upon the two extreames of the Weare two Pilasters either of Wood or Brick; which with the bottome of the Weare do compose our Regulator, wherewith we may make our desired operation, yea the Chanel it self diverted shall serve, without making any other diversion or union. And in brief, if the businesse be but managed by a judicious person, there may wayes and helps be made use of, according to occasion, of which it would be too tedious to speak, and therefore this little that hath been hinted shall suffice.

CONSIDERATION II.

From what hath been declared, if it shall be well understood, may be deduced many benefits and conveniences, not onely in dividing of Running Waters for infinite uses that they are put to in turning of Corne-Mills, Paper-Mills, Gins, Powder-Mills, Rice-Mills, Iron-Mills, Oil-Mills, Sawing-Mills, Mirtle-Mills, Felling-Mills, Fulling-Mills, Silk-Mills, and such other Machines; but also in ordering Navigable Channels, diverting Rivers and Channels of Waters, or terminating and limiting the sizes of Pipes for Fountains: In all which affairs there are great errors committed, to the losse of much expence, the Channels and Pipes that are made, sometimes not being sufficient to carry the designed Waters, and sometimes they are made bigger than is necessary; which disorders shall be avoided, if the Engineer be advised of the things abovesaid: and in case that to these Notions there be added the knowledge of Philosophy and Mathematicks, agreeable to the sublime Discoveries of *Signore Galileo*, and the further improvement thereof by *Signore Evangelista Torricelli*, Mathematician to the Grand Duke of *Tuscany*, who hath subtilly and admirably handled this whole businesse of Motion, one shall then come to the knowledge of particular notions of great curiosity in the Theoricks, and of extraordinary benefit in the Practicks that daily occur in these businesse.

And to shew, in effect, of what utility these Notions are, I have thought fit to insert, in this place, the Considerations by me made upon the Lake of *Venice*, and to represent, at large, by the experience of the last year 1641. the most Serene *Erizzo*, then Duke of the said Republique. Being therefore at *Venice*, in the year aforesaid, I was requested by the most Illustrious and most Excellent *Signore Giovanni Basso*
donna

Donna, a Senâtour of great worth and merit, that I would ingenuously deliver my opinion touching the state of the Lake of *Venice*; and after I had discoursed with his Honour several times, in the end I had order to set down the whole businesse in writing, who having afterwards read it privately, the said *Signore* imparted the same, with like privacy, to the most Serene PRINCE, and I received order to represent the same to the full Colledge, as accordingly I did in the Moneth of *May*, the same year, and it was as followeth.



CONSIDERATIONS

Concerning the

LAKE
OF
VENICE.

BY

D. BENEDETTO CASTELLI,
Abbot of *S. Benedetto Aloysio*, Mathematician to
Pope *URBAN VIII.* and Professor in
ROME.

CONSIDERATION I.



Though the principal cause be but one onely, that in my judgment threatneth irreparable ruine to the Lake of Venice, in the present state in which it now stands; Yet neverthelesse, I think that two Heads may be considered. And this Consideration may peradventure serve us for to facilitate and explain the opportune remedies, though not to render the state of things absolutely unchangeable and eternal: an enterprize impossible, and especially in that which having had some beginning, ought likewise necessarily to have its end; or at least to prevent the danger for many hundreds of years; and possibly it may, in the mean time, by the mutation it self be brought into a better condition.

I say therefore, that the present disorder may be considered under two Heads; One is the very notable discovery of Land that is observed at the time of low Water, the which, besides the obstructing of Navigation in the Lake and also in the Channels, doth likewise threaten another mischief and disorder
worthy

worthy of very particular consideration; which is, That the Sun drying up that mudde, especially in the times of hot Summers, doth raise thence the putrified and pernicious vapours, fogs, and exhalations that infect the Air, and may render the City unhabitable.

The second Head is the great Stoppage that daily is growing in the Ports, especially of *Venice*, at *Malamoco*; concerning which matters I will hint certain general points, and then will proceed to the more particular and important affairs.

And first, I say, that I hold it altogether impossible to effect any thing, though never so profitable, which doth not bring with it some mischief; and therefore the good and the hurt ought to be very well weighed, and then the lesse harmful part to be embraced.

Secondly, I propose to consideration, that the so notable discovery of Earth & Mud, hath not been long observed, as I understand, from old persons that can remember passages for fifty years past; which thing being true, as to me it seemeth most true, it should appear that it could not but be good to reduce matters to that passe that they were at formerly, (laying aside all affection or passion that self-flattering minds have entertained for their own conceits) or at least it shall be necessary speedily to consult the whole.

Thirdly, I hold that it is necessary to weigh, whether from the foresaid discovery of Land, it followeth, that onely the Earth riseth, as it is commonly thought by all, without dispute; or whether the Waters are abated and faine away; or else whether it proceedeth from both the one and other cause. And here it would be seasonable to enquire, what share the said causes may have, each considered apart in the foresaid effect. For, in the first case, if the Earth have been raised, it would be necessary to consider of taking it down, and removing it: But if the Waters have failed or abated, I believe that it would be extreemly necessary to restore and raise them: And if both these reasons have conspired in this effect, it will be necessary to remedy them each apart. And I do, for my part, think, that the so notable appearance of Shelves at the time of low Water, proceeds principally from the decrease and abatement of the Waters, which may confidently be affirmed to need no other proof, in regard that the *Brent* hath been actually diverted which did formerly discharge its Water into the Lake.

As to the other point of the great Stoppage of Ports, I hold, that all proceedeth from the violence of the Sea, which being sometimes disturbed by windes, especially at the time of the waters flowing, doth continually raise from its bottome immense
heaps

heaps of sand, carrying them by the tide; and force of the waves into the Lake; it not having on its part any strength of current that may raise and carry them away, they sink to the bottom, and so they choke up the Ports. And that this effect happeneth in this manner, we have most frequent experiences thereof along the Sea-coasts: And I have observed in *Tuscany* on the *Roman-shores*, and in the Kingdom of *Naples*, that when a river falleth into the Sea, there is alwaies seen in the Sea it self, at the place of the rivers out-let, the resemblance, as it were, of an half-Moon, or a great shelf of settled sand under water, much higher then the rest of the shore, and it is called in *Tuscany*, *il Cavallo*; and here in *Venice*, *lo Scanto*: the which cometh to be cut by the current of the river, one while on the right side, another while on the left, and sometimes in the midst, according as the Wind sits. And a like effect I have observed in certain little Rilllets of water, along the Lake of *Bolsena*; with no other difference, save that of small and great.

Now who so well considereth this effect, plainly seeth that it proceeds from no other, than from the contrariety of the stream of the River, to the *impetus* of the Sea-waves; seeing that great abundance of sand which the Sea continually throws upon the shore, cometh to be driven into the Sea by the stream of the river; and in that place where those two impediments meet with equal force, the sand settleth under water, and thereupon is made that same Shelf or *Cavallo*; the which if the river carry water, and that any considerable store, it shall be thereby cut and broken; one while in one place, and another while in another; as hath been said, according as the Wind blows: And through that Chancel it is that Vessels fall down into the Sea, and again make to the river, as into a Port. But if the Water of the river shall not be continual or shall be weak, in that case the force of the Sea-Wind shall drive such a quantity of sand into the mouth of the Port, and of the river, as shall wholly choak it up. And hereupon there are seen along the Sea-side, very many Lakes and Meers, which at certain times of the year abound with waters, and the Lakes bear down that enclosure, and run into the Sea.

Now it is necessary to make the like reflections on our Ports of *Venice*, *Malamocco*, *Bondolo*, and *Chiozza*; which in a certain sense are no other than Creeks, mouths, and openings of the shore that parts the Lake from the main Sea; and therefore I hold that if the Waters in the Lake were plentiful, they would have strength to scower the mouths of the Ports thorowly, & with great force; but the Water in the Lake failing, the Sea will without any opposal, bring such a drift of sand into the Ports; that if

K k k k

it doth not wholly choke them up, it shall render them at least unprofitable, and impossible for Barks and great Vessels.

Many other considerations might be propounded concerning these two heads of the stoppage of the Ports, and of the appearance of the Ouze and Mud in the Lakes, but so much shall suffice us to have hinted, to make way for discoursing of the operations about the oportune remedies.

Yet before that I propound my opinion, I say, That I know very well that my proposal, at first sight, will seem absurd and inconvenient; and therefore, as such, will perhaps be rejected by the most: and so much the rather, for that it will prove directly contrary to what hath hitherto been, and as I hear, is intended to be done. And I am not so wedded to my opinions, but that I do consider what others may judge thereof: But be it as it will, I am obliged to speak my thoughts freely, and that being done, I will leave it to wiser men than my self; when they shall have well considered my reasons, to judge and deliberate of the *quid agendum*: And if the sentence shall go against me, I appeal to the most equitable and inexorable Tribunal of Nature, who not caring in the least to please either one party or another, will be alwaies a punctual and inviolable executrix of her eternal Decrees, against which neither humane deliberations, nor our vain desires, shall ever have power to rebell. I added by word of mouth that which followeth.

* In *Pregadi*, a particular Council, the Senators of which have great Authority.

Though your Highness interest your self in this Noble Colledge, and cause it to be confirmed in the Senate by universal Vote, that the Winds do not blow, that the Sea doth not fluctuate, that the Rivers do not run; yet shall the Winds be alwaies deaf, the Sea shall be constant in its inconstancy, and the Rivers most obstinate: And these shall be my Judges, and to their determination I refer my self.

By what hath been said, in my opinion, that is made very clear and manifest, which in the beginning of this discourse I glanced at; namely, That the whole disorder, although it be divided into two heads, into the discovery of the Mud, and of the stoppage Ports, yet nevertheless, by the application of one onely remedy, and that in my esteem very easie, the whole shall be removed: And this is; That there be restored into the Lake as much Water as can be possible, and in particular from the upper parts of *Venice*, taking care that the Water be as free from Mud as is possible: And that this is the true and real remedy of the precedent disorders, is manifest: For in the passage that this Water shall make thorow the Lakes, it shall of it self by degrees clear the Channels in sundry parts of them, according to the currents that it shall successively acquire, and in this manner being perfected

perfed thorow the Lake, it fhall maintain the waters in the fame, and in the Chanels much higher, as I fhall prove hereafter; a thing that will make Navigation commodious; and that, which moreover is of great moment in our bufineffe; thofe Shelves of Mud which now discover themselves at the time of Low-Waters fhall be alwayes covered, fo that the putrefaction of the Air fhall alfo be remedied.

And laftly, this abundance of Water being alwayes to difcharge it felf into the Sea by the Ports, I do not doubt, but that their bottomes will be fcoured. And that thefe effects muft follow, Nature her felf feemeth to perfwade, there remaining onely one great doubt, whether that abundance of Water that fhall be brought into the Lake may be really fufficient to make the Waters rife fo much as to keep the Shelves covered, and to facilitate Navigation, which ought to be at leaft half a * Brace, or thereabouts. And indeed it feemeth at firft fight to be impoffible, that the fole Water of the * *Brent* let into the Lake, and difperfed over the fame, can occafion fo notable an height of water; and the more to confirm the difficulties, one might fay, reducing the reafon to calculation, that in cafe the *Brent* were 40. Braces broad, and two and an half high, and the breadth of the Lake were 20000. Braces, it would feem neceffary that the height of the water of the *Brent* dilated and diftended thorow the Lake would be but onely $\frac{1}{100}$ of a Brace in height, which is imperceptible, and would be of no avail to our purpofe; nay more, it being very certain that the *Brent* runneth very muddy and foul, this would occafion very great mifchief, filling and contracting the Lake, and for that reafon this remedy ought, as pernicious, to be totally excluded and condemned.

I here confeffe that I am furprized at the forme of the Argument, as if I were in a certain manner convinced, that I dare not adventure to fay more, or open my mouth in this matter; but the ftrength it felf of the Argument, as being founded upon the means of Geometrical and Arithmetical Calculation, hath opened me the way to discover a very crafty fraud that is couch- ed in the fame Argument, which fraud I will make out to any one that hath but any infight in *Geometry* and *Arithmetick*. And as it is impoffible, that fuch an argument fhould be produced by any but fuch as have tafted of thefe, in fuch affairs, moft profitable, and moft neceffary Sciences; fo do not I pretend to make my felf underftood, fave onely by fuch, to whom I will evince fo clearly, as that more it cannot be defired, the error and fraud wherein thofe Ancients and Moderns have been, and alwayes are intangled, that have in any way yet handled this matter of confidering the Meafure and Quantity of the Waters that move.

K k k k a

And

* A *Venice* Brace
is $\frac{1}{16}$ of our yard.

* A River of
that name.

And so great is the esteem that I have for that which I am now about to say touching this particular, that I am content that all the rest of my Discourse be rejected ; provided, that that be perfectly understood, which I am hereafter to propose, I holding and knowing it to be a main Principle, upon which all that is founded that can be said either well or handsomely on this particular. The other Discourses may have an appearance of being probable, but this hits the mark as full as can be desired, arriving at the highest degree of certainty.

" I. Savii dell' *Acque*, a particular Council that take care of the Lakes and other Aquatick affairs.

I have, seventeen years since, as I represented to the most Serene Prince, and to the Right Honourable the President of the Lords the Commissioners of the *Sewers, written a Treatise of the Measure of the waters that move, in which I Geometrically demonstrate and declare this businesse, and they who shall have well understood the ground of my Discourse, will rest fully satisfied with that which I am now about to propose : But that all may become the more easie, I will more briefly explicate and declare so much thereof as I have demonstrated in the Discourse, which will suffice for our purpose : And if that should not be enough, we have alwayes the experiment of a very easie and cheap way to clear up the whole businesse. And moreover I will take the boldnesse to affirm, that in case there should not for the present any deliberation be made concerning this affair, according to my opinion ; yet neverthelesse it will be, at some time or other ; or if it be not, things will grow worse and worse.

For more clear understanding, therefore, it ought to be known, that it being required, as it is generally used, to measure the waters of a River, its breadth and its depth is taken, and these two dimensions being multiplied together, the product is affirmed to be the quantity of that River : As for example, if a River shall be 100. feet broad, and 20. feet high, it will be said, that that River is 2000 feet of Water ; and so if a Ditch shall be 15. feet broad, and 5. feet high, this same Ditch will be affirmed to be 75. feet of Water : And this manner of measuring Running Water hath been used by the Ancients, and by Moderns, with no other difference, save onely that some have made use of the Foot, others of the Palme, others of the Brace, and others of other measures.

Now because that in observing these Waters that move, I frequently found, that the same Water of the same River was in some sitcs of its Chanel pretty big, and in others much lesse, not arriving in some places to the twentieth, nor to the hundredth part of that which it is seen to be in other places ; therefore this vulgar way of measuring the Waters that move, for that they did
not

not give me a certain and stable measure and quantity of Water, began deservedly to be suspected by me, as difficult and defective, being alwayes various, and the measure, on the contrary, being to be alwayes determinate, and the same; it is therefore written, that *Pondus & Pondus, Mensura & Mensura, utrumque abominabile est apud Deum*, Exod. I considered that in the Territory of *Brescia*, my native Countrey, and in other places, where Waters are divided to overflow the Grounds, by the like way of measuring them, there were committed grievous and most important errors, to the great prejudice of the Publique and of Private persons, neither they that sell, nor they that buy understanding the true quantity of that which is sold and bought: In regard that the same square measure, as is accustomed in those parts, assigned one particular person, carried to sometimes above twice or thrice as much water, as did the same square measure assigned to another. Which thing proveth to be the same inconvenience, as if the measure wherewith Wine and Oil is bought and sold, should hold twice or thrice as much Wine or Oil at one time as at another. Now this Consideration invited my minde and curiosity to the finding out of the true measure of Running Waters. And in the end, by occasion of a most important businessse that I was imployed in some years since, with great intenseness of minde, and with the sure direction of *Geometry*, I have discovered the mistake, which was, that we being upon the businessse of taking the measure of the Waters that move, do make use of two dimensions onely, namely, breadth and depth, keeping no account of the length. And yet the Water being, though running, a Body, it is necessary in forming a conceit of its quantity, in relation to another, to keep account of all the three Dimensions, that is of length, breadth, and depth.

Here an objection hath been put to me, in behalf of the ordinary way of measuring Running Waters, in opposition to what I have above considered and proposed: and I was told, Its true, that in measuring a Body that stands still, one ought to take all the three Dimensions; but in measuring a Body that continually moveth, as the Water, the case is not the same: For the length is not to be had, the length of the water that moveth being infinite, as never finishing its running; and consequently is incomprehensible by humane understanding, and therefore with reason, nay upon necessity it cometh to be omitted.

In answer to this, I say, that in the abovesaid Discourse, two things are to be considered distinctly; First, whether it be possible to frame any conceit of the quantity of the Body of the Water with two Dimensions onely. And secondly, whether this length be to be found. As to the first, I am very certain that no man, let him

him be never so great a Wit, can never promise to frame a conceit of the quantity of the Body of Water, without the third Dimension of length: and hereupon I return to affirm, that the vulgar Rule of measuring Running water is vain and erroneous. This point being agreed on, I come to the second, which is, Whether the third Dimension of length may be measured. And I say, that if one would know the whole length of the water of a Fountain or River, thereby to come to know the quantity of all the Water, it would prove an impossible enterprize, nay the knowing of it would not be useful. But if one would know how much water a Fountain, or a River carrieth in a determinate time of an hour, of a day, or of a moneth, &c. I say, that it is a very possible and profitable enquiry, by reason of the innumerable benefits that may be derived thence, it much importing to know how much Water a Chancel carrieth in a time given; and I have demonstrated the same above in the beginning of this Book; and of this we stand in need in the businesse of the Lake, that so we may be able to determine how much shall be the height of the *Brent*, when it is spread all over the Lake: For the three dimensions of a Body being given, the Body is known; and the quantity of a Body being given, if you have but two dimensions, the third shall be known. And thus diving farther and farther into this Consideration, I found that the Velocity of the course of the water may be an hundred times greater or lesser in one part of its Chancel than in another. And therefore although there should be two mouths of Waters equal in bignesse; yet nevertheless it might come to passe, that one might discharge an hundred or a thousand times more water than another: and this would be, if the water in one of the mouths should run with an hundred or a thousand times greater velocity, than the other; for that it would be the same as to say, that the swifter was an hundred or a thousand times longer, than the slower: and in this manner I discovered that to keep account of the velocity, was the keeping account of the Length.

And therefore it is manifest, that when two Mouths discharge the same quantity of Water in an equal velocity, it is necessary that the less swift Mouth be so much bigger than the more swift; as the more swift exceedeth in velocity the less swift; as for example.

In case two Rivers should carry equal quantity of water in equal times, but that one of them should be four times more swift than the other, the more slow should of necessity be four times more large. And because the same River in any part thereof alwaies dischargeth the same quantity of Water in equal times (as is demonstrated in the first Proposition of the first

Book

Book* of the measure of Running Waters;) but yet doth not run thorowout with the same velocity: Hence it is, that the vulgar measures of the said River, in divers parts of its Chanel, are alwaies divers; insomuch, that if a River passing through its Chanel had such velocity, that it ran 100 Braces in the $\frac{1}{2}$ of an hour, and afterwards the said River should be reduced to so much tardity of motion, as that in the same time it should not run more than one Brace, it would be necessary that that same River should become 100 times bigger in that place where it was retarded; I mean, 100. times bigger than it was in the place where it was swifter. And let it be kept well in mind, that this point rightly understood, will clear the understanding to discover very many accidents worthy to be known. But for this time let it suffice, that we have onely declared that which makes for our purpose, referring apprehensive and studious Wits to the perusal of my aforementioned Treatise; for therein he shall finde profit and delight both together.

Now applying all to our principal intent, I say, That by what hath been declared it is manifest, that if the *Brent* were 40 Braces broad, and 2 $\frac{1}{2}$ high, in some one part of its Chanel, that afterwards the same Water of the *Brent* falling into the Lake, and passing thorow the same to the Sea, it should lose so much of its velocity, that it should run but one Brace, in the time wherein whilst it was in its Chanel at the place aforesaid, it ran 100 Braces. It would be absolutely necessary, that increasing in measure, it should become an hundred times* thicker; and therefore if we should suppose that the Lake were 10000 Braces, the *Brent* that already hath been supposed in its Chanel 100 Braces, being brought into the Lake, should be 100. times 100 Braces; that is, shall be 10000 Braces in thickness, and consequently shall be in height half a Brace; that is, $\frac{1}{2}$ of a Brace, and not $\frac{1}{100}$ of a Brace, as was concluded in the Argument.

Now one may see into what a gross error of 99. in 100. one may fall through the not well understanding the true quantity of Running Water, which being well understood, doth open a direct way to our judging aright in this most considerable affair. And therefore admitting that which hath been demonstrated, I say, that I would (if it did concern me) greatly encline to consult upon the returning of the *Brent* again into the Lake. For it being most evident, that the *Brent* in the Chanel of its mouth, is much swifter than the *Brent* being brought into the Lake, it will certainly follow thereupon, that the thickness of the Water of *Brent* in the Lake, shall be so much greater than that of *Brent* in *Brent*, by how much the *Brent* in *Brent* is swifter than the *Brent* in the Lake.

* He here intends the Demonstrations following, at the end of the first Book

* Deeper;

1. From

1. From which operation doth follow in the first place, that the Lake being filled and increased by these Waters, shall be more Navigable, and passible, than at present we see it to be.
2. By the current of these Waters, the Channells will be scoured, and will be kept clean from time to time.
3. There will not appear at the times of low-waters so many Shelves, and such heaps of Mud, as do now appear.
4. The Ayre will become more wholesom, for that it shall not be so infected by putrid vapours exhaled by the Sun, so long as the Miery Ouze shall be covered by the Waters.
5. Lastly, in the current of these advantageous Waters, which must issue out of the Lake into the Sea, besides those of the Tyde, the Ports will be kept scoured, and clear: And this is as much as I shall offer for the present; touching this weighty buisness; alwaies submitting my self to sounder judgements.

Of the above-said Writing I presented a Copy at *Venice*, at a full Colledge, in which I read it all, and it was hearkned to with very great attention; and at last I presented it to the Duke, and left some Copies thereof with sundry Senators, and went my way, promising with all intenseness to apply my pains with reiterated studies in the publick service; and if any other things should come into my minde, I promised to declare them sincerely, and so took leave of *His serenity*, and that Noble Council. When I was returned to *Rome*, this business night and day continually running in my mind, I hapned to think of another admirable and most important conceit, which with effectual reasons, confirmed by exact operations, I with the Divine assistance, made clear and manifest; and though the thing at first sight seemed to me a most extravagant Paradox, yet notwithstanding, having satisfied my self of the whole business, I sent it in writing to the most Illustrious and most Noble *Signore Gio. Basadonna*; who after he had well considered my Paper, carried it to the Council; and after that those Lords had for many months maturely considered thereon, they in the end resolved to suspend the execution of the diversion which they had before consulted to make of the River *Sile*, and of four other Rivers, which also fall into the Lake; a thing by me blamed in this second Paper, as most prejudicial, and harmful. The writing spake as followeth.

CONSIDERATIONS

Concerning the

LAKE

OF

VENICE.

CONSIDERATION II.



IF the discoursing well about the truth of things, Most Serene Prince, were as the carrying of Burdens, in which we see that an hundred Horses carry a greater weight than one Horse onely; it would seem that one might make more account of the opinion of many men, than of one alone; But because that discoursing more resembleth running, than carrying Burdens, in which we see that one Barb alone runneth faster than an hundred heavy-heel'd Jades; therefore I have ever more esteemed one Conclusion well managed, and well considered by one understanding man, although alone, than the common and Vulgar opinions; especially, when they concern abstruse and arduous points: Nay in such cases the opinions moulded and framed by the most ignorant and stupid Vulgar, have been ever suspected by me as false, for that it would be a great wonder if in difficult matters a common capacity should hit upon that which is handsom, good, and true. Hence I have, and do hold in very great veneration the summe of the Government of the most Serene, and eternal Republick of *Venice*, which although, as being in nature a Common-wealth, it ought to be governed by the greater part; yet nevertheless, in arduous affairs, it is alwaies directed by the Grave Judgement of few, and not judged blindly

LIII

by

by the *Plebeian* Rout. Tis true, that he that propoundeth Propositions far above the reach of common capacity, runneth a great hazard of being very often condemned without further Process, or knowledge of the Cause; but yet for all that, the truth is not to be deserted in most weighry affairs, but ought rather to be explained in due place and time with all possible perspicuity; that so being well understood, and considered, it may come afterwards for the Common good to be embraced.

This which I speak in general, hath often been my fortune in very many particulars, not onely when I have kept within the bounds of meer speculation, but also when I have chanced to descend to Practice, and to Operations: and your Highness knoweth very well what befel me the last Summer 1641. when in obedience to your Sovereign Command, I did in full Colledge represent my thoughts touching the state of the Lake of *Venice*; for there not being such wanting, who without so much as vouchsafing to understand me, but having onely had an inkling, and bad apprehension of my opinion, fell furiously upon me, and by violent means both with the Pen and Prefs, full of Gall, did abuse me in reward of the readines that I had exprest to obey and serve them: But I was above measure encouraged and pleased, to see that those few who vouchsafed to hear me, were all either thorowly perswaded that my opinion was well grounded, or at least suspended their prudent verdict to more mature deliberation. And though at the first bout I chanced to propose a thing that was totally contrary to the most received and antiquated opinion, and to the resolutions and consultations taken above an hundred years ago: Moved by these things, and to satisfie also to the promise that I had made of tendering unto them what should farther offer it self unto me touching the same business; I have resolved to present to the Throne of your Highness, another Consideration of no less importance, which perhaps at first sight will appear a stranger Paradox; but yet brought to the Test and Touch-stone of experience, it shall prove most clear and evident. If it shall be accounted of, so that it succeedeth to the benefit of your Highness, I shall have obtained my desire and intent; And if not, I shall have satisfied my self, and shall not have been wanting to the Obligation of your most faithful Servant, and native Subject.

That which I propounded in the Mouths pass, touching the most important business of the Lake, though it did onely expressly concern the point of the diversion of the Mouth of the Lake, already made and put in execution; yet it may be understood and applied also to the diversion under debate, to be made of the other five Rivers, and of the *Sile* in particular.

Now

Now touching this, I had the fortune to offer an admirable accident that we meet with when we come to the effect, which I verily believe will be an utter ruine to the Lake of Venice.

I say therefore, that by diverting these five Rivers, that remain, although their water that they discharge for the present into the Lake is not all taken together; parts of what the *Brent* alone did carry, yet neverthelesse the abatement of the water of the Lake which shall ensue upon this last diversion of four parts, which was the whole water, shall prove double to that which hath happened by the diversion of *Brent* onely, although that the *Brent* alone carried five parts of that water, of which the Rivers that are to be diverted carry four: A wonder really great, and altogether unlikely; for the reducing all this Proposition to be understood, is as if we should say, that there being given us three Rivers, of which the first dischargeth five parts, the second three, and the third one, and that from the diversion of the first, there did follow such a certain abatement or fall; from the taking away of the second there ought to follow also so much more abatement; And lastly, from the withdrawing of the third the water ought to fall so much more, which is wholly impossible: And yet it is most certain, and besides the demonstration that perswades me to it, which I shall explain in due time, I can set before your eyes such an experiment as is not to be denied by any one, although obstinate: and I will make it plainly seen and felt, that by taking away only four parts of the five, which shall have been taken away, the abatement proveth double to the abatement ensuing upon the diverting first of the five onely; which thing being true, as most certainly it is, it will give us to understand how pernicious this diversion of five Rivers is like to prove, if it shall be put in execution.

By this little that I have hinted, and the much that I could say, let your Highnesse gather with what circumspection this businessse ought to be managed, and with how great skill he ought to be furnished who would behave himself well in these difficult affairs.

I have not at this time explained the demonstration, nor have I so much as propounded the way to make the Experiment, that I am able to make in confirmation of what I have said, that so by some one or others mis-apprehending the Demonstration, and maiming the Experiment, the truth may not happen to shine with lesse clarity than it doth, when all mists of difficulty are removed: and if so be, no account should be made of the Reasons by me alledged, and that men should shut their eyes against the Experiments that without cost or charge may be made, I do de-

LIII

clare

clare and protest that there shall follow very great dammages to the Fields of the main Land, and extraordinary summes shall be expended to no purpose. The Lake undoubtedly will become almost dry, and will prove impassible for Navigation, with a manifest danger of corrupting the Air: And in the last place there will unavoidably ensue the choaking and stoppage of the Ports of *Venice*.

Upon the 20th. of *December*, 1641. I imparted this my second Consideration to the most Excellent *Signore Basadonna*, presenting him with a Copy thereof amongst other Writings, which I have thought good to insert, although they seem not to belong directly to our businesse of the Lake.

The way to examine the MUD and SAND
that entereth and remaineth in the
LAKE of *VENICE*.

To the most Excellent

SIGNORE GIO. BASADONNA.

TWO very considerable Objections have been made against my opinion concerning the Lake of *Venice*: One was that, of which I have spoken at large in my first Consideration, namely, that the *Brents* having been taken out of the Lake, cannot have been the occasion of the notable fall of the Waters in the Lake, as I pretend, and consequently, that the turning *Brent* into the Lake would be no considerable remedy, in regard that the water of *Brent*, and the great expansion of the Lake over which the water of *Brent* is to diffuse and spread being considered, it is found that the rise proveth insensible.

The second Objection was, that the *Brent* is very muddy, and therefore if it should fall muddy into the Lake, the Sand would sink and fill up the same.

Touching the first Query, enough hath been said in my first Consideration, where I have plainly discovered the deceit of the Argument, and shewn its fallacy; It remaineth now to examine the

the second : to which in the first place I say, that one of the first things that I proposed in this affair was, that I held it impossible to do any act, though never so beneficial, that was not also accompanied by some inconvenience and mischief; and therefore we are to consider well the profit, and the losse and prejudice; and they both being weighed, we shall be able to choole the lesser evil: Secondly, I admit it to be most true, that *Brent* is at some times muddy, but it is also true, that for the greater part of the year it is not muddy. Thirdly, I do not see nor understand what strength this objection hath, being taken so at large, and in general; and methinks that it is not enough to say, that the *Brent* runneth muddy, and to assert that it deposeth its Muddiness in the Lake, but we ought moreover to proceed to particulars, and shew how much this Mud is, and in what time this choaking up of the Ports may be effected. For the Reasons are but too apparent and particular, that conclude the ruine of the Lake, and that in a very short time, (for mention is made of dayes) the Waters diversion being made, and moreover we have the circumstance of an Experiment, the state of things being observed to have grown worse since the said diversion. And I have demonstrated, that in case the Diversion of the *Sile* and the other Rivers should be put in execution, the Lake would in a few dayes become almost dry; and the Ports would be lost, with other mischievous consequences. But on the other side, although that we did grant the choaking of them, we may very probably say, that it will not happen, save onely in the succession of many and many Centuries of years. Nor can I think it prudent counsel to take a resolution and imbrace a Designe now, to obtain a benefit very uncertain, and more than that, which only shall concern those who are to come very many Ages after us, and thereby bring a certain inconvenience upon our selves, and upon our children that are now alive and present.

Let it be alledged therefore, (although I hold it false) that by the diversions of the Rivers the Lake may be kept in good condition for several years to come.

But I say confidently, and hope to demonstrate it; That the Diversions will bring the Lake, even in our dayes, to be almost dry, and at least will leave so little water in it, that it shall cease to be Navigable, and the Ports shall most infallibly be choaked up. I will therefore say upon experience, in answer to this Objection, that it is very necessary first well to discourse, and rationally to particularize and ascertain the best that may be this point of the quantity of this sinking Mud or Sand.

Now I fear I shall make my self ridiculous to those, who measuring the things of Nature with the shallownesse of their brains
do

do think that it is absolutely impossible to make this enquiry, and will say unto me, *Quis mensus est pugillo aquas, & terram palmo ponderavit?* Yet nevertheless I will propound a way whereby, at least in gross, one may find out the same.

Take a Vessel of Cylindrical Figure, holding two barrels of water, or thereabouts; and then fill it with the water of *Brent*, at its Mouth or Fall into the Lake; but in the Lake at the time that the *Brent* runneth muddy, and after it hath begun to run muddy for eight or ten hours, to give the mud time to go as far as *S. Nicolo*, to issue into the Sea; and at the same time take another Vessel, like, and equal to the first, and fill it with the water of the Lake towards *S. Nicolo*, (but take notice that this operation ought to be made at the time when the waters go out, and when the Sea is calm) and then, when the waters shall have settled in the aforesaid Vessels, take out the clear water, and consider the quantity of Sand that remains behind, and let it be set down, or kept in mind: And I am easily induced to think, that that shall be a greater quantity of Sand which shall be left in the first Vessel, than that left in the second Vessel. Afterwards when the *Brent* shall come to be clear, let both the operations be repeated, and observe the quantity of Sand in the aforesaid Vessels; for if the Sand in the first Vessel should be most, it would be a sign, that in the revolution of a year the *Brent* would depose Sand in the Lake: And in this manner one may calculate to a small matter what proportion the Sand that entreth into the Lake, hath to that which remains: And by that proportion one may judge how expedient it shall be for publick benefit. And if at several times of the year you carefully repeat the same operations, or rather observations, you would come to a more exact knowledge in this business: And it would be good to make the said operations at those times, when the Lake is disturbed by strong high Winds, and made muddy by its own Mud, raised by the commotion of the Waters.

This notion would give us great light, if the same observations should be made towards the Mouth of *Lio*, at such time as the waters flow and ebb, in calm seasons; for so one should come to know whether the waters of the Lake are more thick at the going out, than at the entrance. I have propounded the foregoing way of measuring Sands and Mud, to shew that we are not so generally, and inconsiderately to pronounce any sentence, but proceed to stricter inquiries, and then deliberate what shall be most expedient to be done. Others may propose more exquisite examinations, but this shall serve me for the present.

I will add onely, that if any one had greater curiosity (it would be profitable to have it) in investigating more exactly the quantity

tity of the Water that entereth into the Lake, by the means that I have shewen in the beginning of this Book: When he shall have found the proportion of the quantity of water to the quantity of Sand or Mud, he shall come to know how much Sand the *Brent* shall leave in the Lake in the space of a year. But to perform these things, there are required persons of discretion, and fidelity, and that are employed by publick Order; for there would thence result eminent benefit and profit.

Here are wanting LETTERS from several persons.

To the Reverend Father, *Francesco di*
S. GIUSEPPE.

IN execution of the command that you laid upon me in your former Letters, by order from the most Serene, my Lord, Prince Leopold; that I should speak my judgement concerning the disimboquement of the River called *Fiume morto*, whether it ought to be let into the Sea, or into *Serchio*; I say, that I chanced 18. years since to be present, when the said Mouth was opened into the Sea, and that of *Serchio* stoped; which work was done to remedy the great Innundation that was made in all that Country, and Plain of *Pisa*, that lyeth between the River *Arno*, and the Mountains of *S. Giuliano*, and the River *Serchio*; which Plain continued long under water, insomuch that not onely in the Winter, but also for a great part of the Summer, those fields were overflowed; and when that the Mouth of *Fiume morto* was effectually opened into the Sea, the place was presently freed from the waters. and drained, to the great satisfaction of the Owners of those Grounds. And here I judge it worth your notice, that for the generality of those that possess estates in those parts, they deved that the Mouth of *Fiume morto* might stand open to the Sea; and those who would have it open into *Serchio*, are persons that have no other concernment there, save the hopes of gaining by having the dispose of Commissions, and the like, &c.

But for the more plain understanding of that which is to be said, it must be known, That the resolution of opening the said Mouth into *Serchio*, was taken in the time of the Great Duke *Ferdinando* the first, upon the same motives that are at this time again proposed, as your Letters tell me, Since that, it manifestly appearing, that *Fiume morto* had, and hath its Mouth open to the Sea, the Plain hath been kept dry; and it being also true, that the

the fury of the South, and South-West-Winds, carried such abundance of sand into the Mouth, or Out-let of *Fiume morto*, that it wholly stopp'd it up: especially when the waters on *Pisa* side were low and shallow. And they think, that turning the Lake of *Fiume morto* into *Serchio*, and the *Serchio* maintaining continually its own Mouth with the force of its waters open to the Sea, and consequently also *Fiume morto*, they would have had the Out-let clear and open; and in this manner they think, that the Plain of *Pisa* would have been freed from the waters. The business passeth for current, at first sight; but experience proveth the contrary, and Reason confirmeth the same: For the height of the water of those Plains, was regulated by the height of the waters in the Mouth of *Fiume morto*; that is, The waters at the Mouth being high, the waters also do rise in the fields; and when the waters at the Mouth are low, the waters of the fields do likewise abate: Nor is it enough to say, That the Out-let or Vent of *Fiume morto* is continual, but it must be very low: Now if *Fiume morto* did determine in *Serchio*, it is manifest that it would determine high; for *Serchio* terminating in the Sea, when ever it more and more aboundeth with water, and riseth, it is necessary that also *Fiume morto* hath its level higher, and consequently shall keep the waters in the Plains higher. Nay, it hath happened sometimes (and I speak it upon my own sight) that *Fiume morto* hath reversed its course upwards towards *Pisa*; which case will ever happen, whensoever the *Pisan* waters chance to be lower than the level of those of *Serchio*; for in that case the waters of *Serchio* return back upon the Plains thorow *Fiume morto* in such sort, that the Muddinesses, and the *Serchio* have been observed to be carried by this return as far as the Walls of *Pisa*; and then before such time as so great waters can be aswaged, which come in with great fury, and go out by little and little, there do pass very many days, and moneths; nay sometimes one being never able to find the waters of *Serchio*, when at the shallowest, so low as the Sea in level; (which is the lowest place of the waters) it thence doth follow, that the waters of *Fiume morto* should never at any time of the year, so long as they determine in *Serchio*, be so low, as they come to be when the same *Fiume morto* determineth in the Sea. Tis true indeed, that the Mouth of *Fiume morto*, opened into the Sea, is subject to the inconvenience of being stopp'd up by the force of Winds: But in this case, it is necessary to take some pains in opening it; which may easily be done, by cutting that Sand a little which stayeth in the Mouth, after that the Wind is laid; and it is enough if you make a Trench little more than two Palms in breadth; for the water once beginning to run into it, it will in a few hours carry that

that Sand away with it, and there will ensue a deep and broad Trench that will drain away all the water of the Plains in very little time. And I have found by practice, that there having been a great quantity of Sand driven back, by the fury of the South-West-Wind, into the Mouth of *Fiume morto*, I having caused the little gutter to be made in the Morning, somewhat before Noon, a Mouth hath been opened of 40. Braces wide, and notably deep, insomuch that the water, which before had incommoded all the Champian ran away in less than three dayes, and left the Country free and dry, to the admiration of all men. There was present upon the place, at this business, on the same day that I opened the Mouth, the most Serene great Duke, the most Serene Arch-Dutchess Mother, all the Commissioners of Sewers, with many other Persons and Peasants of those parts; and they all saw very well, that it was never possible that a little Bark of eight Oars, which was come from *Legorn* to wait upon the great Duke, should ever be able to master the Current, and to make up into *Fiume morto*; and his Highness, who came with an intent to cause the said Mouth towards the Sea to be stopt; and that into *Serchio* to be opened, changed his judgement, giving order that it should be left open towards the Sea, as it was done. And if at this day it shall return into *Serchio*, I am very certain that it will be necessary to open it again into the Sea. And there was also charge and order given to a person appointed for the purpose, that he should take care to open the said Mouth, as hath been said upon occasion. And thus things have succeeded very well unto this very time. But from the middle of *October*, until this first of *February*, there having continued high South, and South-West-Winds, with frequent and abundant Rains; it is no wonder that some inundation hath happened; but yet I will affirm, that greater mischiefs would have followed, if the Mouth had been opened into *Serchio*. This which I have hitherto said, is very clear and intelligible to all such as have but competent insight, and indifferent skill in these affairs. But that which I am now about to propose farther, will, I am very certain, be understood by your self, but it will seem strange and unlikely to many others. The point is, that I say; That by raising the level of *Fiume morto*, one half Brace, onely at its Mouth, (it will penetrate into *Serchio* farther than it would into the Sea) it shall cause the waters to rise three, or perhaps more Braces upon the fields towards *Pisa*, and still more by degrees as they shall recede farther from the Sea-side; and thus there will follow very great Inundations, and considerable mischiefs. And to know, that this is true, you are to take notice of an accident, which I give warning of in my discourse of the Measure of Running Waters.

M m m m

where

where also I give the reason thereof, * *Coroll. 14.* The accident is this, That there coming a Land-Flood, for example, into *Arno*, which maketh it to rise above its ordinary Mouth wthin *Pisa*, or a little above or below the City six or seven Braces; this same height becometh alwaies lesser and lesser, the more we approach towards the Sea-side; insomuch, that near to the Sea the said River shall be raised hardly half a Brace: Whence it followeth of necessary consequence, that should I again be at the Sea-side, and knowing nothing of what hapneth, should see the River *Arno* raised by the accession of a Land-flood, one third of a Brace; I could certainly infer, that the same River was raised in *Pisa* those same six or seven Braces. And that which I say of *Arno*, is true of all Rivers that fall into the Sea. Which thing being true, it is necessary to make great account of every small rising, that *Fiume morto* maketh towards the Sea-side by falling into *Serchio*. For although the rising of *Fiume morto*, by being to disgorge its Waters into *Serchio*, towards the Sea, were onely a quarter of a Brace; we might very well be sure, that far from the Sea, about *Pisa*, and upon those fields the rise shall be much greater, and shall become two or three Braces: And because the Countrey lyeth low, that same rise will cause a continual Inundation of the Plains, like as it did before; I caused the Mouth to be opened into the Sea. And therefore I conclude that the Mouth of *Fiume morto*, ought by no means to be opened into *Serchio*, but ought to be continued into the Sea, using all diligence to keep it open after the manner aforesaid, so soon as ever the Wind shall be laid. And if they shall do otherwise, I confidently affirm, that there will daily follow greater damages; not onely in the Plains, but also in the wholesomness of the Air; as hath been seen in times past. And again, It ought with all care to be procured, that no waters do by any means run or fall from the Trench of *Libra*, into the Plain of *Pisa*, for these Waters being to discharge into *Fiume morto*, they maintain it much higher than is imagined, according to that which I have demonstrated in my consideration upon the state of the Lake of *Venice*. I have said but little, but I speak to you, who understandeth much, and I submit all to the most refined judgment of our most Serene Princee *Leopold*, whose hands I beseech you in all humility to kiss in my name, and implore the continuance of his Princely favour to me; and so desiring your prayers to God for me, I take my leave.

Your most affectionate Servant,

Rome 1. Feb.

1642.

D. BENEDETTO CASTELLI.

The

The answer to a Letter written by BAR-
TOLOTTI, touching the
difficultyes observed.

*The former part of the Letter is omitted, and the discourse
beginneth at the first Head.*

And first I say, Whereas I suppose that the level of the *Serchio* is higher than that of *Fiume morto*; this is most true, at such time as the waters of *Fiume morto* are discharged into the Sea; but I did never say that things could never be brought to that pass, as that the level of *Fiume morto* should be higher than *Serchio*: and so I grant that it will follow, that the waters of *Fiume morto* shall go into *Serchio*, and its very possible, that the Drain of *Fiume morto* into *Serchio* may be continueate; and I farther grant, that its possible, that the *Serchio* doth never disgorge thorow *Fiume morto* towards *Pisa*; Nay, I will yet farther grant that it might have happened, that *Fiume morto* might have had such a fall into *Serchio*, as would have sufficed to have turned Mills: But then I add withall, that the Plains of *Pisa*, and the City it self must be a meer Lake.

2. *Signore Bartolotti* saith confidently, that when the Sea swelleth by the South-West, or other Winds, the level of *Serchio* in the place marked A in the Platt, distant about 200. Braces, riseth very little: But that *Fiume morto* in D, and in E, many miles more up into Land riseth very much, and that certain Fishermen confirm this, and shew him the signes of the rising of the Water. I grant it to be very true, and I have seen it with my own eyes: But this cometh to pass, when the Mouth of *Fiume morto* is stopt up by the Sea; as I shall shew by and by. And this rising near the Sea-side, is of no considerable prejudice to the fields. And this is as much as I find to be true in the assertion of *Signore Bartolotti*, (without his confirming it by any other proof; as indeed it needs none) That the level of *Fiume morto* riseth in E, and many miles farther upwards it riseth much; nor did I ever affirm the contrary.

3. Concerning the difficulty of opening the Mouth of *Fiume morto* into the Sea, that which *Il Castellano* saith is most certain; namely, That at the entrance upon the opening of the Mouth, it is necessary to make a deep Trench: But I say, that at that time it is difficult to open it, unless upon great occasions; for that the

M m m m 2

difficulty

difficulty proceedeth from the waters of *Fiume morto* being low, and the fields drained.

4. As to the particular of the Causes that you tell me men press so much unto the most Serene *Grand Duke*, and to the Prince, I have not much to say, because it is not my profession; nor have I considered of the same: Yet I believe, that when the Prince and his Highnesse see the benefit of his People and Subjects in one scale of the Ballance, and the accomodation of Huntsmen in the other, his Highnesse will incline to the profit of his subjects; such have I alwayes found his Clemency and Noblenesse of minde. But if I were to put in my vote upon this businesse, I would say, that the points of Spears, and the mouths of Guns, the yelping of Dogs, the wilynesse of Huntsmen, who run thorow and narrowly search all those Woods, Thickets and Heathes, are the true destroyers of Bucks and Boares, and not a little Salt-water, which setleth at last in some low places, and spreadeth not very far. Yet neverthelesse, I will not enter upon any such point, but confine my self tolely to the businesse before me.

5. That Experiment of joyning together the water of *Fiume morto*, and that of *Serchio* by a little trench to see what advantage the Level E hath upon the Level I, doth not give me full satisfaction, taken so particularly, for it may come to passe, that sometimes E may be higher, and sometimes A lower, and I do not question but that when *Serchio* is low, and *Fiume morto* full of Water, the level of *Fiume morto* will be higher than that of *Serchio*. But *Serchio* being full, and *Fiume morto* scant of Water, the contrary will follow, if the Mouth shall be opened to the Sea. And here it should seem to me, that it ought to be considered, that there is as much advantage from E to the Sea through the little Trench opened anew into *Serchio*, as from E to the Sea by the Mouth of *Fiume morto*. But the difficulty (which is that we are to regard in our case) is, that the course of the Waters thorow the Trench is three times longer than the course of the Mouth of *Fiume morto*, as appeareth by the Draught or Plat which you sent me, which I know to be very exactly drawn, for that the situation of those places are fresh in my memory. Here I must give notice, that the waters of *Fiume morto* determining thorow the Trench in *Serchio* (the waters of which *Fiume morto* are, for certain, never so low as the Sea) their pendency or declivity shall, for two causes, be lesse than the pendency of those waters through the Mouth towards the Sea, that is, because of the length of the line through the Trench, and because of the height of their entrance into *Serchio*, a thing which is of very great import in discharging the waters which come suddenly, as
he

he shall plainly see, who shall have understood my Book of the Measure of Running Waters. And this was the Reason why all the Countrey did grow dry upon the opening of the Mouth into the Sea. And here I propose to consideration that which the Peasants about *Pisa* relate, namely, That the Water in the Fields doth no considerable harm by continuing there five or six, yea, or eight dayes. And therefore the work of the Countrey is to open the Mouth of *Fiume morto*, in such manner, that the Water being come, they may have the Trench free and ready, when that the Water cometh it may have a free drain, and may not stay there above eight or nine dayes, for then the overflowings become hurtful. It is to be desired also, that if any Proposition is produced touching these affairs, it might be propounded the most distinctly that may be possible, and not consist in generals, especially when the Dispute is of the risings, of velocity, of tardity, of much and little water; things that are all to be specified by measures.

6. Your Letter saith, in the next place, that *Signore Bartolotti* confesseth, that if the Mouth of the *Fiume morto* might alwayes be kept open, it would be better to let it continue as it is: the which, that I may not yield to him in courtesie, I confesse, for the keeping it stopt on all sides would be a thing most pernicious. But admitting of his confession I again reply, that *Fiume morto* ought not to be let into *Serchio*, but immediately into the Sea; because although sometimes the Mouth to Seawards be stopt up, yet for all that, the raising of the Bank above the Plains (which is all the businesse of importance) shall be ever lesfer, if we make use of the Mouth leading to the Sea, than using that of *Serchio*.

7. I will not omit to mention a kinde of scruple that I have concerning the position of *Sign. Bartolotti*, that is, where he saith that the two Mouths A and D are equal to the like Mouths into the Sea; Now it seems to me, that the Mouth A of *Fiume morto* into *Serchio* is absolutely within *Serchio*, nor can it be made lower, and is regulated by the height of *Serchio*. But the Mouth of *Fiume morto* terminates, and ought to be understood to terminate in the Sea it self, the lowest place. And this I believe was very well perceived by *Sig. Bartolotti*, but I cannot tell why he past it over without declaring it: and we see not that the Mouth D falleth far from the Sea, which Mouth ought to be let into the Sea it self, and so the advantage of the Mouth into the Sea more clearly appeareth.

8. That which *Sig. Bartolotti* addeth, that when it is high Waters, at such time as the Waters are out, and when Winds choak up *Fiume morto*, they not only retard it, but return the
course

course of the Waters upwards very leasurely, perswadeth me more readily to believe that *Sig. Bartolotti* knoweth very well, that the Mouth of *Fiume morto* let into *Serchio* is hurtful : for by this he acknowledgeth that the Mouth towards the Sea doth in such sort drain the Countrey of the Waters, as that they become very low ; and therefore upon every little *impetus* the waters turn their course : And from the motions, being exceeding flow, is inferred, that the abundance of Sea-water that cometh into *Fiume morto*, is so much as is believed, and as *Sig. Bartolotti* affirmeth.

9. After that *Sig. Bartolotti* hath said what he promiseth above, namely, that when the Windes blowing strongly do stop up *Fiume morto*, and not onely retard but turn the course upwards, the time being Rainy, and the Mouth of *Fiume morto* shut up, the Waves of the Sea passe over the Bank of *Fiume morto*; at that time, saith *Signore Bartolotti*, the Champain shall know the benefit of *Fiume morto* discharged into *Serchio*, and the mouth A shall stand alwayes open ; and *Fiume morto* may alwayes constantly run out, as also the Rains and Rain-waters, although the hurtful Tempest should last many dayes, &c. And I reply, that all the Art consists in this ; for the benefit of those Fields doth not depend on, or consist in saying, that *Fiume morto* is alwayes open, and *Fiume morto* draineth continually ; But all the businesse of profit lyeth and consisteth in maintaining the Waters low in those Plaines, and those Ditches, which shall never be effected whilst the World stands, if you let *Fiume morto* into *Serchio* ; but yet it may, by opening the mouth into the Sea : and so much reason and nature proveth, and (which importeth) Experience confirmeth.

10. In the tenth place I come to consider the answer that was made to another Proposition in the Letter which I writ to Father *Francesco*, which prudently of it self alone might serve to clear this whole businesse. I said in my Letter, That great account is to be made of every small rising and ebbing of the Waters neer to the Sea in *Fiume morto*, for that these risings and fallings, although that they be small neer to the Sea-side, yet nevertheless, they operate and are accompanied by notable risings and fallings within Land, and far from the Sea-side, and I have declared by an example of *Arno*, in which a Land-flood falling, that made it increase above its ordinary height within *Pisa* six or seven Braces, that this height of the same Flood becometh still lesser, the neerer we approach to the Sea-coasts. Nor shall the said River be raised hardly half a Brace ; whereupon it necessarily followeth, that if I should return to the Sea-side, and not knowing any thing of that which happeneth at *Pisa*, and seeing the

the River *Arno* raised by a Land-flood half a Brace, I might confidently affirm the said River to be raised in *Pisa* those six or seven Braces, &c. From suchlike accidents I conclude in the same Letter, that it is necessary to make great account of every little rise that *Fiume morto* shall make towards the Sea. Now cometh *Bartolotti* (and perhaps because I knew not how to express myself better, understandeth not my Proposition) and speaketh that which indeed is true, but yet besides our case: Nor have I ever said the contrary; and withall doth not apply it to his purpose. Nay I say; that if he had well applyed it, this alone had been able to have made him change his opinion. And because he saith; that I said, that it is true, when the abatement proceedeth from some cause above, as namely by Rain, or opening of Lakes; But when the cause is from below, that is, by some stop, as for instance some Fishers Wears or Locks; or some impediment remote from the Sea, although at the Level it shall rise some Braces where the impediment is, yet that rising shall go upwards; and here he finisheth his Discourse, and concludeth not any thing more. To which I say first, that I have also said the same in the Proposition, namely, that a Flood coming (which maketh *Arno* to rise in *Pisa* six or seven Braces (which I take to be a superiour cause whether it be Rain or the opening of Lakes, as best pleaseth *Bartolotti*) in such a case I say, and in no other (for towards the Sea-coasts it shall not cause a rising of full half a Brace; and therefore seeing *Arno* at the Sea-side to be raised by a Flood, whether of Rain, or of opening of Lakes half a Brace) it may be inferred, that at *Pisa* it shall be raised those six or seven Braces; which variety, well considered, explaineth all this affair in favour of my opinion: For the rising that is made by the impediment placed below, of Fishing Weares and Locks, operateth at the beginning, raising the Waters that are neer to the impediment; and afterwards less and less, as we retire upwards from the impediment: provided yet that we speak not of a Flood that cometh by accession, but onely of the ordinary Water impeded. But there being a new accession, as in our case, then the Water of the Flood, I say, shall make a greater rising in the parts superiour, far from the impediment; and these impediments shall come to be those that shall overflow the Plains, as happened eighteen or nineteen years ago, before the opening of *Fiume morto* into the Sea, The same will certainly follow, if *Fiume morto* be let into *Serchio*. Here I could alledge a very pretty case that befell me in *la Campagna di Roma*, neer to the Sea-side. where I drained a Bog or Fen, of the nature of the Waters of *Pisa*, and I succeeded in the enterprize, the Waters in their first towards the Sea abating only three Palmes, and yet in the

* The Countrey
or Province lying
round the City
heretofore called
Lati

Fen

Fen they fell more than fifteen Palmes. But the businesse would be long, and not so easily to be declared, and I am certain that *Sig. Bartolotti* having considered this, would alter his judgment, and withall would know that remitting that impediment anew, which I had left for lesse than three Palmes towards the Sea, the Waters in the Fen would return with the first Floods and Raines to the same height as before, as likewise *Fiume morto* will do if it shall be let again into *Serchio*.

Here I intreat your Honour to do me the favour to importune *P. Francesco* in my behalf, that he would be pleased to declare my meaning in the aforesaid Letter to *Sig. Bartolotti*, for I hope that if he will understand this point, he will be no longer so tenacious in his opinion.

Next that these Lords in the Commission of Sewers, with the Right Honourable the Marquesse of *S. Angelo*, and your Honour do approve of my judgment, doth very much rejoyce me; but because that I know that they do it not in design to complement me, but onely to serve his Highness our Grand Duke, I freely profess that I will pretend no farther obligations from them therein, than I account my self to owe to those whose opinions are contrary to mine, for that I know that they have the same end. The definitive sentence of this whole busines is, that they give these Plains, these Draines, and these Waters farre fetcht appellations.

11. As to the quantity of the Water that *Fiume morto* dischargeth into the Sea, there are very great disputes about it, and I have been present at some of them. But let your Honour believe me, that as this is not continual, but only during a few dayes, so it will never be of any great prejudice to these Fields; and if your Lordship would be ascertained thereof, you may please to go to *Fiume morto* at about a mile's distance from the Sea, in the time of these strong Windes, and observe the current from thence upwards, for you shall finde it extream slow, and consequently will know that the quantity of the Water that is repuls'd is very small. And this seems to be contradicted by the rule of Risings proceeding from causes below, which occasion no considerable alteration far from the Sea.

I am necessitated to go to morrow out of *Rome* with his Eminence Cardinal *Gaetano* about certain affairs touching Waters, therefore I shall not farther enlarge, but for a close to this tedious Discourse, I conclude in few words, that *Fiume morto* is by no means to be let into *Serchio*, nor are there any means intermediate courses to be taken, for they will alwayes be prejudicial; but *Fiume morto* is to be discharged immediately into the Sea. When it is stoppt up by the fury of the Sea-waves, I affirm that it is a
sign

sign that there is no need of opening it; and if there be any occasion to open it, it is easily done. As for the rest your Lordship may please to keep account of all the particulars that occur, for the memory of things past is our Tutresse in those that are to come. If occasion shall offer, I intreat you to bow humbly in my name to His Highness the Grand Duke, and the most Serene Prince *Leopold*; and to attend the service of Their Highnesses, for you serve Princes of extraordinary merit; And to whom I myself am also exceedingly obliged. In the controversies that arise respect the pious end of speaking the Truth, for then every thing will succeed happily. I kiss the hands of *Padre Francesco*, of *Sig. Bartolotti*, and of your Lordship.

Your Honours

Rome, 14. March 1642.

most Obliged Servant

D. BENEDETTO CASTELLI.

Vpon this occasion I will here insert a Discourse that I made upon the Draining and improvement of the *Pontine Fens*, for that I think that whatsoever may be done well and to purpose in this matter hath absolute dependance on the perfect knowledge of that so important Proposition, by me demonstrated and explained in my Treatise of the *Mensuration of Running Waters*, namely, That the same water of a River doth continually change Measures, according as it altereth and changeth the velocity of its course; so that the measure of the thicknesse of a River in one Site, to the measure of the same River in another Site, hath the same proportion reciprocally that the velocity in this site hath to the velocity in the first site. And this is a Truth so constant and unchangeable, that it altereth not in the least point on any occurrences of the Waters that change: and being well understood, it openeth the way to the knowledge of fundry advertisements in these matters, which are all resolved by this sole Principle; and from it are derived very considerable benefits; and without these it is impossible to do any thing with absolute perfection.

N O N N

A

The first thing that I observed when I came to the
city of London was the great number of churches
and the great number of people. The city was
very large and the people were very busy.
I saw many people walking in the streets
and many people riding in the carriages.
The city was very beautiful and the people
were very kind. I saw many people
walking in the streets and many people
riding in the carriages. The city was
very beautiful and the people were very
kind. I saw many people walking in the
streets and many people riding in the
carriages. The city was very beautiful and
the people were very kind.

The second thing that I observed when I came to the
city of London was the great number of churches
and the great number of people. The city was
very large and the people were very busy.

THE HISTORY OF THE

When I came to the city of London, I saw many
people walking in the streets and many people
riding in the carriages. The city was very
beautiful and the people were very kind. I
saw many people walking in the streets and
many people riding in the carriages. The city
was very beautiful and the people were very
kind. I saw many people walking in the
streets and many people riding in the
carriages. The city was very beautiful and
the people were very kind. I saw many
people walking in the streets and many
people riding in the carriages. The city was
very beautiful and the people were very
kind. I saw many people walking in the
streets and many people riding in the
carriages. The city was very beautiful and
the people were very kind.

A
CONSIDERATION

Upon the

DRAINING

OF THE

Pontine Fenns.

BY

D. BENEDETTO CASTELLI, Abbot
of S. BENEDETTO ALOISIO, and Professor
of the *Mathematicks* to P. Urban VIII. in the
Univerſity of R O M E.

CONSIDERATION III.



Amongſt the enterprizes by me eſteemed; if not abſolutely impoſſible, , at leaſt exceeding difficult, one was that famous one of Draining the *Pontine Fenns*; and therefore I was thorowly reſolved never to apply my minde thereunto, although by my Patrons I ſhould be commanded to the ſame: accounting that it was an occaſion rather of loſing reputation by the miſcarriage of the attempt, than of gaining fame by reducing things to a better paſs then they now are at. Yet nevertheless, having of late years obſerved the place, and ſailed through thoſe Channels, and thoſe Waters; after I had made ſome reflection thereupon, I thought that the enterprize was not ſo difficult as I had at firſt conceited it to be; and I am the more confirmed in this opinion, upon the inducement of that which I have written

N n n n 2

Geo

Geometrically in my Treatise of the Mensuration of Running Waters; so that talking with several persons, I adventured to affirm, in discourse, that this improvement might possibly be brought into a good estate.

Now I have resolved to set down my thoughts in writing, and to honour this my Paper with the Noble Name of your Lordship, to render it the more credible and conspicuous at the first view, if it should chance that the Subject I treat of, were not of such moment, as that it did deserve to be valued for any other reason. Pardon me, Sir, if I have been too bold, and continue me in the number of your Servants.

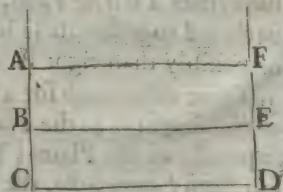
The enterprize of Draining a great part of the Territories of the Pontine Fenns, hath been undertaken both in the time of the ancient Romans, and last of all, in our days; yea in the late times by Sixtus V. I do not doubt in the least, but that it will be possible yet to reduce things to a very good pass; and if I be not mistaken, with a very small charge in comparison of the profit that would be received from those rich Grounds. This improvement was of great expence in the time of Sixtus Quintus, but by reason the thing was not rightly understood, there were made many Drains; a great part of which were unprofitable and vain: and amongst so many operations, there hapned some to be made that succeeded, as was desired; but not being understood, they were held in no account; and thus the business being neglected, the waters are returned into the same state as they were at first, before the improvement. Here I have by familiar discourses with my friends, explained this enterprize undertaken by Sixtus V. and haply also by some more antient, with the example of the Fable of Orilo, in Ariosto. This Monster was made up with such enchantment, that men fought with him alwayes in vain; for though in the Combate he were cut in pieces, those divided Members presently re-united, and returned to the fight more fierce then ever. But the Paladine Astolfo coming to undertake him, after a long dispute, at the end he cut his head sheer off from the shoulders at one blow; and nimbly alighting from his Horse, took the Monstrous head, and mounting again, as he rid away he fell to shave the Pole of that Monster, and so he lost the Lock of Hair, in which alone the enchantment lay; and then the horrible Head in an instant manifested signs of death, and the trunk which ran, seeking to reunite to it anew, gave the last gasp, and in this manner the enchantment ended. The Book of Fate served admirably to the Paladine, whereby he came to understand that Charm; for by shaving his whole head, the enchanted hairs came to be cut off amongst the rest: In the same manner, I say, that it hath sometimes happened in Draining those Fields;

for

for that amongst so many tryals as have been made, that also was light upon, on which the improvement and remedy to the disorder did depend. And to us my fore-named Treatise shall serve for a Rule, which being well understood, shall make us to know wherein consisteth, and whereon dependeth this miscarriage, and consequently it will be easie to apply thereunto a reasonable remedy.

And first I say, That there is no doubt but that the waters continue so high on those Plains because they are so high in the principal River, which ought to receive them, and carry them into the Sea. Now the Causes of the height of the River, may in my judgement be reduced to one alone; which is that by me so often mentioned for the most Potent one, and declared in my afore-named Tractate; to wit, The tardity of the motion of the waters, which doth alwayes infallibly, and precisely cause the self same Running Water to change the measure of its thickness at such a rate, that the more it encrease in velocity, the more it decrease in measure; and the more it decrease in velocity, the more it encrease in measure: As for example; If a River run in such a place with the velocity of moving a mile in the space of an hour, and afterwards the same River in another place doth encrease in velocity, so as to make three miles an hour; that same River shall diminish in thickness two thirds: And on the contrary, If it shall diminish in velocity so, as that it runneth but half a mile in the same time, it shall encrease the double in thickness and measure. And in a word, look what proportion the velocity in the first place, hath to the velocity in the second, and such hath reciprocally the measure of the thickness in the second place, to the measure in the first; as I have clearly demonstrated in my Treatise: Which I repeat so frequently, that I fear the Professors of Polite Learning will charge me with Tautologie, and vain Repetition. But I am so desirous in this most important point to be well understood, because it will then be easie to comprehend all the rest; and without this it is impossible (I will not say difficult, but absolutely impossible) to understand, or ever to effect any thing to purpose. And the better to explain the example, let it be supposed,

That the water of a River A D, runneth high at the level of A F, with such a certain velocity; and let it, by the same water, be velocitated three times more; I say, that it will abate; and shall stand at the level in B E; and if it shall more velocitate, it will abate the more at the Sea; But if it should retard



more

more than it did at the level A F, it would rise yet more above the said level A F; although that the self same quantity of water runneth all the while. By the above-named solid Principle I resolve extravagant Problems in my Treatise; and assign the Reasons of admirable effects of Running Waters: But as for what concerneth our purpose of the *Pontine Fenns*, we have the Causes very plain and clear; for which, by the trampling of Cattle which pass thorow the *Draining River*, the waters abate so notably, that it is as it were a miracle for those Reeds, Flags, and Weeds that spring up, encrease, and spread all over the River, stop and impede that velocity of the waters which they would have by means of their declivity. But that passage of those Beasts, treading down those Weeds unto the bottom of the River, in such sort, as that they no longer hinder the Current of the Water; and the same Waters increasing in their course, they do diminish in measure and height; and by this means the Ditches of the Plains empty into the same successfully, and leave them free from Waters, and Drained. But these Weeds in a short time sprouting up anew, and raising their stalkes thorow the body of the Waters, they reduce things to the same evil state, as before, retarding the velocity of the Water, making it to increase in height, and perhaps do occasion greater mischiefs; seeing that those many knots which each plant shoots forth, begets a greater multitude of Stalks, which much more incumbering the Water of the River, are a greater impediment unto its velocity, and consequently make the height of the waters to encrease so much the more, and do more mischief than before.

Another head to which these harms may be reduced, but proceeding from the same Root, which hath a great part in this disorder, is the impediment of those Wears in the River which are made by heightning the bed of the same, for placing of fishing-nets; of which *Piscaries* I reckoned above ten, when I made a voyage thorow those waters to *Sandolo*. And these Fishing-Wears are such impediments, that some one of them makes the water of the River in the upper part to rise half a Palm, and sometimes a whole Palm, and more; so that when they are all gathered together, these impediments amount to more than seven, or possibly than eight Palms.

There concurrereth for a third most Potent Cause of the waters continuing high in the evacuating, or Draining Chanel, and consequently on the Plains; The great abundance of water that issueth from *Fiume Sisto*, the waters of which do not keep within its Banks when they are abundant; but encreasing above its Chanel, they unite with those of the Evacuator, and dispersing thorow
the

the Fens are raised with great prejudice, and much greater than is conceived, according to what hath been demonstrated in the Second Consideration upon the *Lake of Venice*. Nor is it to any purpose to say, that if we should measure all the Waters that disimbogue from *Fiume Sisto*, and gather them into one summe, we should not finde them to be such, as that they shall be able to make the Waters of the Fens to increase, by reason of the great expansion of them, over which that body of water is to distend: for to this instance we answer with that which we have given notice of in the First Consideration touching the *Lake of Venice*, treating of the abatement that is caused by the *Brent* let into the Lake. And moreover, if I shall add thereto that which I write in the Second Consideration, it will be very apparent how greatly harmful and prejudicial these excursions of Waters from *Fiume Sisto* may be, which are not kept under, and confined within the River: Therefore, proceeding to the provisions, and operations that are to be accounted Principall; I reduce them to three Heads.

In the first place it is necessary to throw down those Weares, and to take the Piscaries quite away, observing a Maxime, in my judgment, infallible, that Fishing and Sowing are two things that can never consist together; Fishing being on the Water, and Sowing on land.

Secondly, it will be necessary to cut under Water in the bottome of the River those Weeds and Plants that grow and increase in the River, and leave them to be carried into the Sea by the Stream; for by this means these Reeds shall not spring up and distend along the bottome of the River, by means of the Beasts treading upon them; And the same ought to be done often, and with care, and must not be delayed till the mischief increase, and the Champain Grounds be drowned, but one ought to order matters so, as that they may not drown. And I will affirm, that otherwise this principal point would become a most considerable inconvenience.

Thirdly, it is necessary to make good the Banks of *Fiume Sisto* on the left hand, and to procure that those Waters may run in the Chanel, and not break forth. And it is to be noted, that it is not enough to do one or two of those things, but we are to put them all in execution; for omitting any thing, the whole machine will be out of tune, and spoiled. But proceeding with due care, you shall not only Drain the *Pontine Fens*; but by means of this last particular the Current of *Fiume Sisto* shall scowr its own Chanel of its self, even to the carrying part of it away: and haply with this abundance of water that it shall bear

bear, the Mouth *della Torre* may be opened, and kept open into the Sea. And it would, last of all, be of admirable benefit to cleanse *Fiume Sisto* from many Trees and Bushes where with it is overgrown.

And with this I conclude, that the Improvement or Drain possible to be made consisteth in these three particulars. First, in taking away the Fishing Weares, leaving the Course of the Waters free. Secondly, in keeping the Principal Rivers clear from Weeds and Plants. Thirdly, in keeping the water of *Fiume Sisto* in its own Chanel. All which are things that may be done with very little charge, and to the manifest benefit of the whole Country, and to the rendering the Air wholsomer in all those Places adjoyning to the *Pontine Fens*.



A
CONSIDERATION

Upon the

DRAINING

Of the Territories of

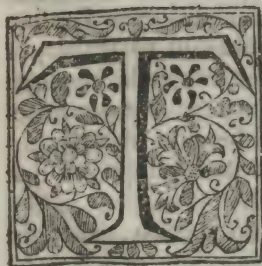
Bologna, Ferrara,

AND

Romagna.

BY

D. BENEDETTO CASTELLI, Abbot
of S. BENEDETTO ALOISIO, *Mathematician*
to P. Urban VIII. and Professor in the
Univerſity of R O M E.



He weghly buſineſſe of the Draining of
the Territories of Bologna, Ferrara,
and Romagna having been punctually
handled and declared in writing from
the excellent memory of the Right Ho-
nourable and Noble *Monſignore Corſini*,
who was heretofore Deputed Commiſ-
ſary General, and Viſitor of thoſe Wa-
ters; I am not able to make ſuch ano-
ther Diſcourſe upon the ſame Subject, but will only ſay ſome-
what for farther confirmation of that which I have ſaid in this
Book upon the *Lake of Venice*, upon the *Pontine Fens*, and up-
on the Draining of thoſe Plains of *Piſa*, lying between the Ri-
vers *Arno* and *Serchio*; whereby it is manifeſt, that in all the

OOO

afore-

aforementioned Cases, and in the present one that we are in hand with, there have, in times past, very grosse Errours been committed, through the not having ever well understood the true measure of Running waters; and here it is to be noted, that the businesse is, that in *Venice*, the diversion of the waters of the Lake, by diverting the *Brent* was debated, and in part executed, without consideration had how great abatement of water might follow in the Lake, if the *Brent* were diverted, as I have shewn in the first Consideration upon this particular, from which act there hath ensued very bad consequences, not only the difficulty of Navigation, but it hath infected the wholesomnesse of the Air, and caused the stoppage of the Ports of *Venice*. And on the contrary, the same inadvertency of not considering what rising of the Water the *Reno*, and other Rivers being opened into the Valleys of *Bologna* and *Ferrara*, might cause in the said Valleys, is the certain cause that so many rich and fertile Fields are drowned under water, converting the happy habitations and dwellings of men into miserable receptacles for Fishes: Things which doubtlesse would never have happened, if those Rivers had been kept at their height, and *Reno* had been turn'd into *Main-Po*, and the other Rivers into that of *Argenta*, and of *Volano*. Now there having sufficient been spoken by the above-named *Monfig. Corsini* in his Relation, I will only adde one conceit of my own, which after the Rivers should be regulated, as hath been said, I verily believe would be of extraordinary profit, I much doubt indeed that I shall finde it a hard matter to perswade men to be of my mind, but yet nevertheless I will not question, but that those, at least, who shall have understood what I have said and demonstrated concerning the manners and proportions, according to which the abatements and risings of Running waters proceed, that are made by the Diversions and Introductions of Waters, will apprehend that my conjecture is grounded upon Reason. And although I descend not to the exactnesse of particulars, I will open the way to others, who having observed the requisite Rules of considering the quantity of the waters that are introduced, or that happen to be diverted, shall be able with punctuality to examine the whole businesse, and then resolve on that which shall be expedient to be done.

Reflecting therefore upon the first Proposition, that the Risings of a Running Water made by the accession of new water into the River, are to one another, as the Square-Roots of the quantity of the water that runneth; and consequently, that the same cometh to pass in the Diversions: Insomuch, that a River running in height one such a certain measure, to make it encrease double in height, the water is to be encreased to three times as much

much as it ran before; so that when the water shall be quadruple, the height shall be double; and if the water were centuple, the height would be decuple onely, and so from one quantity to another: And on the contrary, in the Diversions; If of the 100. parts of water that run thorow a River, there shall be diverted $\frac{1}{10}$, the height of the River diminisheth onely $\frac{1}{10}$, and continuing to divert $\frac{1}{10}$, the height of the River abateth likewise $\frac{1}{10}$, and so proceeding to divert $\frac{1}{10}$ and then $\frac{1}{10}$, and then $\frac{1}{10}$, and then $\frac{1}{10}$, and then $\frac{1}{10}$, and then $\frac{1}{10}$, alwaies by each of these diversions, the height of the Running Water diminisheth the tenth part: although that the diversions be so unequal. Reflecting I say upon this infallible Truth, I have had a conceit, that though the *Reno* and other Rivers were diverted from the Valleys, and there was onely left the *Chanel of Navigation*, which was onely the $\frac{1}{10}$ part of the whole water that falleth into the Valleys; yet nevertheless, the water in those same Valleys would retain a tenth part of that height that became conjoynd by the concurrence of all the Rivers: And therefore I should think that it were the best resolution to maintain the *Chanel of Navigation* (if it were possible) continue unto the *Po* of *Ferrara*, and from thence to carry it into the *Po* of *Volano*; for besides that it would be of very great ease in the Navigation of *Bologna*, and *Ferrara*; the said water would render the *Po* of *Volano* navigable as far as to the very Walls of *Ferrara*, and consequently the Navigation would be continue from *Bologna* to the Sea-side.

But to manage this enterprize well, it is necessary to measure the quantity of the Water that the Rivers discharge into the Valleys, and that which the *Chanel of Navigation* carryeth, in manner as I have demonstrated at the beginning of this Book; for this once known, we shall also come to know, how profitable this diversion of the *Chanel of Navigation* from the Valleys is like to prove; which yet would still be unprofitable, if so be that all the Rivers that discharge their waters into the Valleys, should not first be Drained, according to what hath been above advertised.

Abbot CASTELLI, in the present consideration referring himself to the Relation of Monsig. Corsini, grounded upon the Observations and Precepts of the said Abbot; as is seen in the present Discourse. I thought it convenient for the compleating of the Work of our Author, upon these subjects, to insert it in this place.

A

Relation of the Waters in the Territories
of *Bologna* and *Ferrara*.

B Y

The Right Honourable and Illustrious, *Monfig-
nore* CORSINI, a Native of *Tuscany*, Su-
perintendent of the general DRAINS,
and President of *Romagna*.

THe *Rheno*, and other Brooks of *Romagna*, were by the
advice of *P. Agostino Spennazzati* the Jesuite, towards
the latter end of the time of *Pope Clement VIII.* notwith-
standing the opposition of the *Bolognesi*, and others concerned
therein, diverted from their Channels, for the more commodious
cleansing of the *Po* of *Ferrara*; and of its two Branches of *Prima-
ro*, and *Volano*; in order to the introducing the water of the
Main-Po into them, to the end that their wonted Torrents being
restored, they might carry the Muddy-water thence into the Sea,
and restore to the City the Navigation which was lost, as is ma-
nifest by the Brief of the said *Pope Clement*, directed to the *Car-
dinal San Clemente*, bearing date the 22. of *August*, 1604.

The work of the said cleansing, and introducing of the said
Po, either as being such in-it self, or by the contention of the
Cardinal Legates then in these parts; and the jarrings that hap-
ned betwixt them, proved so difficult, that after the expence of
vast sums in the space of 21. years, there hath been nothing
done, save the rendring of it the more difficult to be effected.

Interim, the Torrents with their waters, both muddy and
clear, have damaged the Grounds lying on the right hand of the
Po of *Argenta*, and the *Rheno* those on its Banks; of which I
will speak in the first place, as of that which is of greater impor-
tance, and from which the principal cause of the mischiefs that
result from the rest doth proceed.

* Or Lordship.

This *Rheno* having overflowed the * Tennency of *Sanmartina*,
in circumference about fourteen miles given it before, and part
of that of *Cominale* given it afterwards, as it were, for a recepta-
cle; from whence, having deposed the matter of its muddiness,
it issued clear by the Mouths of *Masi*, and of *Lievaloro*, into
the *Po* of *Primaro*, and of *Volano*; did break down the encom-
passing

passing Bank or Dam towards *S. Martino*, and that of its new Chanel on the right hand neer to *Torre del Fondo*.

By the breaches on this side it streamed out in great abundance from the upper part of *Cominale*, and in the parts about *Raveda*, *Pioggio*, *Caprara*, *Ghiare di Reno*, *Sant' Agostino*, *San Prospero*, *San Vincenzo*, and others, and made them to become incultivable: it made also those places above but little fruitful, by reason of the impediments that their Draines received, finding the Conveyances called *Riolo* and *Scorsuro*, not only filled by *la Motta* and *la Belletta*, but that they turned backwards of themselves.

But by the Mouths in the inclosing Bank or Dam at *Borgo di S. Martino* issuing with violence, it first gave obstruction to the ancient Navigation of *la Torre della Fossa*, and afterwards to the moderne of the mouth of *Masi*, so that at present the Commerce between *Bologna* and *Ferrara* is lost, nor can it ever be in any durable way renewed, whilst that this exceeds its due bounds, and what ever moneys shall be employed about the same shall be without any equivalent benefit, and to the manifest and notable prejudice of the * Apostolick Chamber.

* The Popes
Exchequer.

Thence passing into the Valley of *Marzara*, it swelleth higher, not only by the rising of the water, but by the raising of the bottome, by reason of the matter sunk thither after Land-floods, and dilateth so, that it covereth all the Meadows thereabouts, nor doth it receive with the wonted facility the Drains of the upper Grounds, of which the next unto it lying under the waters that return upwards by the Conveyances, and the more remote, not finding a passage for Rain-waters that settle, become either altogether unprofitable or little better.

From this Valley, by the Trench or Ditch of *Marzara*, or of *la Duca* by *la Buova*, or mouth of *Castaldo de Rossi*, and by the new passage it falleth into the *Po* of *Argenta*, which being to receive it clear, that so it may sink farther therein, and receiving it muddy, because it hath acquired a quicker course, there will arise a very contrary effect.

Here therefore the superficies of the water keeping high, until it come to the Sea, hindereth the Valleys of *Ravenna*, where the River *Senio*, those of *San Bernardino* where *Santerno* was turned, those of *Buon'acquisto*, and those of *Marmora*, where the *Idice*, *Quaderna*, *Sellero* fall in, from swallowing and taking in their Waters by their usual In-lets, yet many times, as I myself have seen in the *Visitation*, they drink them up plentifully, whereupon, being conjoyned with the muddiness of those Rivers that fall into the same, they swell, and dilate, and overflow some grounds, and deprive others of their Drains in like manner

as hath been said of that of *Marrara*, inſomuch that from the Point of *S. Giorgio*, as far as *S. Alberto* all thoſe that are between the Valleys and *Po* are ſpoiled, of thoſe that are between Valley and Valley many are in a very bad condition; and thoſe that are ſome conſiderable ſpace above not a little damaged.

† *Poleſine* is a
plat of Ground al-
moſt ſurrounded
with Bogs or wa-
ters, like an Iſland

In fine, by raiſing the bottom or ſand of the Valleys; and the bed of *Reno*, and the too great repletion of the *Po* of *Primaro* with waters, the Valleys of *Comacchio* (on which ſide the Banks are very bad) and * *Poleſine di S. Giorgio* are threatned with a danger, that may in time, if it be not remedied, become irreparable, and at preſent feelth the incommodity of the Waters, which penetrating thorow the pores of the Earth do ſpring up in the ſame, which they call *Purlings*, which is all likely to redound to the prejudice of *Ferrara*, ſo noble a City of *Italy*, and ſo important to the *Eccleſiaſtick State*.

* People of *Ferrara*.

Which particulars all appear to be attested under the hand of a Notary in the *Viſitation* which I made upon the command of His Holineſſe, and are withall known to be true by the **Ferrareſi* themſelves; of whom (beſides the request of the *Bologneſi*) the greater part beg compaſſion with ſundry *Memorials*, and remedies, as well for the miſchiefs paſt, as alſo for thoſe in time to come, from which I hold it a duty of Conſcience, and of Charity to deliver them.

Pope *Clement* judged, that the ſufficient means to effect this was the ſaid Introduction of the *Main Po* into the Chanel of *Ferrara*; a reſolution truly Heroical, and of no leſſe beauty than benefit to that City, of which I ſpeak not at preſent, becauſe I think that there is need of a readier and more accommodate remedy.

* In Channels
made by hand.

So that I ſee not how any other thing can be ſo much conſiderable as the removal of *Reno*, omitting for this time to ſpeak of *incloſing it from Valley to Valley untill it come to the Sea, as the Dukes of *Ferrara* did deſign, forasmuch as all thoſe *Ferrareſi* that have intereſt in the *Poleſine di S. Giorgio*, and on the right hand of the *Po* of *Argenta* do not deſire it, and do, but too openly, proteſt againſt it; and becauſe that before the Chanel were made as far as the Sea, many hundreds of years would be ſpent, and yet would not remedy the dammages of thoſe who now are agrieved, but would much increaſe them, in regard the Valleys would continue ſubmerged, the Drains ſtopped, and the other Brooks obſtructed, which would of neceſſity drown not a few Lands that lie between Valley and Valley; and in fine, in regard it hath not from *San Martina* to the Sea for a ſpace of fifty miles a greater fall then 19, 8, 6, feet, it would want that force which they themſelves who propound this project do require it to have

have, that so it may not depose the matter of the muddiness when it is intended to be let into *Volana*.

So that making the Line of the bottome neer to *Vigarano*, it would rise to those prodigious termes that they do make bigger, and they may thence expect those mischiefs, for which they will not admit of introducing it into the said *Po* of *Volana*.

Amongst the wayes therefore that I have thought of for effecting that same remotion, and which I have caused to be viewed by skilful men that have taken a level thereof, (with the assistance of the venerable Father, *D. Benedetto Castelli* of *Casina*, a man of much fidelity and honesty, and no less expert in such like affairs touching waters, than perfect in the *Mathematick* Disciplines) two onely, the rest being either too tedious, or too dangerous to the City, have seemed to me worthy, and one of them also more than the other, to offer to your Lordship.

The one is to remit it into the Chanel of *Volana*, thorow which it goeth of its own accord to the Sea.

The other is to turn it into *Main-Po* at *Stellata*, for, as at other times it hath done, it will carry it to the Sea happily.

As to what concerns the making choice of the first way, that which seemeth to perswade us to it is, that we therein do nothing that is new, in that it is but restored to the place whence it was removed in the year 1522. in the time of Pope *Adrian*, by an agreement made in way of contract, between *Alfonso*, Duke of *Ferrara*, and the *Bolognesi*; and that it was diverted for reasons, that are either out of date, or else have been too long time deferred.

In like manner the facility wherewith it may be effected, letting it run into the divided *Po*, whereby it will be turned to *Ferrara*, or else carrying it by *Torre del Fondo*, to the mouth of *Masi*, and from thence thorow the Trench made by the *Ferraresi*, along by *Panaro*, where also finding an ample Bed, and high and thick Banks, that will serve at other times for it, and for the waters of *Po*, there may a great expence be spared.

That what ever its Fall be, it would maintain the same, not having other Rivers, which with their Floods can hinder it; and that running confined between good Banks, without doubt it would not leave *la Motto* by the way; but especially, that it would be sufficient if it came to *Codigoro*, where being assisted by the Ebbing and Flowing of the Sea, it would run no hazard of having its Chanel filled up from thence downwards.

That there might thence many benefits be derived to the City, by means of the Running Waters, and also no mean Navigation might be expected.

On the contrary it is objected, That it is not convenient to think

think of returning this Torrent into the divided Po, by reason of the peril that would thence redound to this City.

And that going by *Torre del Fondo*, through *Sanmartina* to the Mouth de *Masi* by the Chappel of *Vigarano* unto the Sea, it is by this way 70. miles; nor is the Fall greater than 26. 5. 6. Feet, so that it would come to fall but 4. inches & an half, or thereabouts in a mile; whereas the common opinion of the skilfull (to the end that the Torrents may not depole their sand that they bring with them in Land-Floods) requireth the twenty fourth part of the hundredth part of their whole length, which in our case, accounting according to the measure of these places, is 16. inches a mile; whereupon the sinking of the Mud and Sand would most certainly follow, and so an immense heightning of the Line of the Bottom, and consequently a necessity of raising the Banks, the impossibility of maintaining them, the danger of breaches and decayes, things very prejudicial to the *Islets* of this City, and of *San Giorgio*, the obstruction of the Drains, which from the Tower of *Tienne* downwards, fall into the said Chanel, to wit, those of the Sluices of *Goro*, and the Drains, of the Meadows of *Ferrara*: And moreover, the damages that would arise unto the said *Islet* of *S. Giorgio*, and the Valleys of *Comachio*, by the waters that should enter into the *Goro* or Dam of the Mills of *Belri-guardo*, thorow the Trenches of *Quadrea*, which cannot be stopt, because they belong to the Duke of *Modena*, who hath right of diverting the waters of that place at his pleasure to the work of turning Mills.

*The inch of these places is somewhat bigger than ours.

The greater part of which Objections, others pretend to prove frivolous, by saying, that its running there till at the last it was turned another way, is a sign that it had made such an elevation of the Line, of its Bed as it required; denying that it needeth so great a declivity as is mentioned above; and that for the future it would rise no more.

That the said Drains and Ditches did empty into the same, whilst Po was there; so that they must needs be more able to do so when onely *Reno* runs that way.

That there would no Breaches follow; or if they did, they would be onely of the water of *Reno*, which in few hours might be taken away (in those parts they call damming up of Breaches, and mending the Bank, taking away the Breaches) and its a question whether they would procure more inconvenience than benefit, for that its Mud and Sand might in many places, by filling them up, occasion a seasonable improvement.

Now omitting to discourse of the solidity of the reasons on the one side, or on the other, I will produce those that move me to suspend my allowance of this design.

The

The first is, that although I dare not subscribe to the opinion of those that require 16. inches Declivity in a mile to *Reno*, to prevent its depositing of Mud; yet would I not be the Author that should make a trial of it with so much hazard, for having to satisfy my self in some particulars caused a Level to be taken of the Rivers *L' amone*, *Senio*, and *Santerno*, by *Bernardino Aleotti*, we found that they have more Declivity by much than Artists require; as also the *Reno* hath from *la Botta de Ghislieri* to the Chappel of *Vigarano*, for in the space of four miles its Bottom-Line falleth five feet and five inches. So that I hold it greater prudence to depend upon that example, than to go contrary to a common opinion, especially since, that the effects caused by *Reno* it self do confirm me in the same, for when it was forsaken by the *Po*, after a few years; either because it had choaked up its Chanel with Sand, or because its too long journey did increase it, it also naturally turned aside, and took the way of the said *Po* towards *Stellata*. Nay, in those very years that it did run that way, it only began (as relations say) to make Breaches, an evident sign that it doth depose Sand, and raise its Bed; which agreeth with the testimony of some that were examined in the Visitation of the Publique Notary, who found great benefit by having Running Water, and some kind of passage for Boats, and yet nevertheless affirm that it for want of Running Water had made too high Stoppages and Shelves of Sand; so that if it should be restored to the Course that it forsook, I much fear that after a short time, if not suddenly, it would leave it again.

The second I take from the observation of what happened to *Panaro*, when with so great applause of the *Ferarese*, it was brought by Cardinal *Serra* into the said Chanel of *Volana*; for that notwithstanding that it had Running Waters in much greater abundance than *Reno*; yet in the time that it continued in that Chanel it raised its Bed well near five feet, as is to be seen below the Sluice made by Cardinal *Capponi* to his new Chanel; yea, the said Cardinal *Serra* who desired that this his undertaking should appear to have been of no danger nor damage, was constrained at its Overflowings, to give it Vent into *Sanmartina*, that it might not break in upon, and prejudice the City; which danger I should more fear from *Reno*, in regard it carrieth a greater abundance of Water and Sand.

Thirdly, I am much troubled (in the uncertainty of the success of the affair) at the great expence thereto required; For in regard I do not approve of letting it in, near to the Fortresse, for many respects, and carrying it by *la Torre del Fondo* to the Mouth de *Mesi*; it will take up eight miles of double Banks, a

P p p p

thing

thing not easie to be procured, by reason that the Grounds lie under Water; but from the Mouth *de Masi* unto *Codigoro*, it would also be necessary to make new Scowrings of the Chancel; to the end, that the Water approaching (by wearing and carrying away the Earth on both shores, might make a Bed sufficient for its Body, the depth made for *Panaro* not serving the turn, as I conceive; and if it should suffice, when could the people of *Ferrara* hope to be re-imburied and satisfied for the charge thereof?

Fourthly, it serves as an Argument with me, to see that the very individual persons concerned in the Remotion or Diversion of the said Torrent, namely, the *Bolognesi* do not incline unto it, and that the whole City of *Ferrara*, even those very persons who at present receive damage by it, cannot indure to hear thereof. The reason that induceth these last named to be so averse thereto, is, either because that this undertaking will render the introduction of the Water of *Main-Po* more difficult; or because they fear the danger thereof; The others decline the Project, either for that they know that *Reno* cannot long continue in that Course, or because they fear that it is too much exposed to those men-revengeful Cutting of it who do not desire it should; and if a man have any other wayes, he ought, in my opinion, to forbear that, which to such as stand in need of its Removal, is lesse satisfactory, and to such as oppose it, more prejudicial.

To conclude, I exceedingly honour the judgment of Cardinal *Capponi*, who having to his Natural Ability and Prudence added a particular Study, Observation, and Experience of these Waters for the space of three years together, doth not think that *Reno* can go by *Volana*; to which agreeth the opinion of Cardinal *S. Marcello*, Legate of this City, of whom, for his exquisite understanding, we ought to make great account. But if ever this should be resolved on, it would be materially necessary to unite the Quick and Running Waters of the little Chancel of *Genio*, of the Chancel *Navilio*, of *Guazzaloca*, and at its very beginning those of *Dardagna*, which at present, is one of the Springs or Heads of *Panaro*, that so they might assist it in carrying its Sand, and the matter of its Muddiness into the Sea; and then there would not fail to be a greater evacuation and scowring; but withall the Proprietors in the Islet of *San Giorgio* and of *Ferrara* must prepare themselves to indure the inconveniences of Purlings or Sewings of the Water from the River thorow the Boggy Ground thereabouts.

I should more easily incline therefore to carry it into *Main-Po* at *Stellata*, for the Reasons that Cardinal *Capponi* most ingeniously enumerates in a short, but well-grounded Tract of his: not because

because that indeed it would not both by Purlings and by Breaches occasion some inconvenience; especially, in the beginning: but because I hold this for the incomodities of it, to be a far less evil than any of the rest; and because that by this means there is no occasion given to them of *Ferrara*, to explain that they are deprived of the hope of ever seeing the *Po* again under the Walls of their City: To whom, where it may be done, it is but reason that satisfaction should be given.

It is certain that *Po* was placed by Nature in the midst of this great Valley made by the *Appennine* Hills, and by the Alps, to carry, as the Master-Drain to the Sea, that is the grand receptacle of all Waters; those particular streams which descend from them.

That the *Reno* by all Geographers; *Strabo*, *Pliny*, *Solimas*, *Mella*, and others is enumerated among the Rivers that fall into the said *Po*.

That although *Po* should of it self change its course, yet would *Reno* go to look it out, if the works erected by humane industry did not obstruct its passage; so that it neither is, nor ought to seem strange, if one for the greater common good should turn it into the same.

Now at *Stellata* it may go several waies into *Po*, as appeareth by the levels that were taken by my Order; of all which I should best like the turning of it to *la Botta de' Ghislieri*, carrying it above *Bondeno* to the Church of *Gambarone*, or a little higher or lower, as shall be judged least prejudicial, when it cometh to the execution, and this for two principal reasons: The one because that then it will run along by the confines of the Church Patrimony, without separating *Ferrara* from the rest of it; The other is, Because the Line is shorter, and consequently the fall greater; for that in a space of ten miles and one third, it falleth twenty six feet, more by much than is required by Artists; and would go by places where it could do but little hurt, notwithstanding that the persons interessed study to amplify it incredibly.

On the contrary, there are but onely two objections that are worthy to be examined; One, That the Drains and Ditches of *S. Bianca*, of the Chanel of *Cento*, and of *Burana*, and all those others that enter into *Po*, do hinder this diversion of *Reno*, by the encreasing of the waters in the *Po*. The other is that *Po* rising about the Transom of the *Pilaster-Sluice*, very near 20 feet, the *Reno* would have no fall into the same; whereupon it would rise to a terrible height, at which it would not be possible to make, or keep the Banks made, so that it would break out and drown the Meadows, and cause mischiefs, and damages unspeakable and irreparable; as is evident by the experiment made upon

P p p p 2

Pana-

Panaro, which being confined between Banks, that it might go into *Po*, this not being neither in its greatest excrefcence, it broke out into the territories of *Final*, and of *Ferrara*. And though that might be done, it would thereupon enfue, that there being let into the Chanel of *Po*, 2800. fquare feet of water (for fo much we account thofe of *Reno* and *Panaro*, taken together in their greateft heights) the fuperficies of it would rife at leaft four feet, infomuch that either it would be requifite to raife its Banks all the way unto the Sea, to the fame height, which the treasures of the *Indies* would not fuffice to effect; or elfe there would be a neceffity of enduring exceffive Breaches. To thefe two Heads are the Arguments reduced, which are largely amplified againft our opinion; and I fhall answer firft to the laft, as moft material.

I fay therefore, that there are three cafes to be confidered: Firft, *Po* high, and *Reno* low. Secondly, *Reno* high, and *Po* low. Thirdly, *Reno* and *Po* both high together.

As to the firft and fecond, there is no difficulty in them; for if *Po* fhall not be at its greateft height, *Reno* fhall ever have a fall into it; and there fhall need no humane Artifice about the Banks: And if *Reno* fhall be low, *Po* fhall regurgitate and flow up into the Chanel of it; and alfo from thence no inconvenience fhall follow. The third remains, from which there are expected many mifchiefs; but it is a moft undoubted truth, that the excrefcencies of *Reno*, as coming from the adjacent *Appennines* and Rains, are to continue but feven, or eight hours at moft, and fo would never, or very rarely happen to be at the fame time with thofe of *Po*, caufed by the melting of the fnowes of the Alps, at leaft 400. miles diftance from thence. But becaufe it fometimes may happen, I reply, that when it cometh to pafs, *Reno* fhall not go into *Po*, but it fhall have allowed it one or two Vents; namely, into the Chanel of *Ferrara*, as it hath ever had; and into *Saumartina*, where it runneth at prefent, and wherewith there is no doubt, but that the perfons concerned will be well pleafed, it being a great benefit to them, to have the water over-flow their grounds once every four or five years, inftead of feeing it anoy them continually. Yea, the Vent may be regulated, referving for it the Chanel in which *Reno* at prefent runneth; and inftead of turning it by a Dam at *la Betta de Ghiflieri*, perhaps, to turn it by help of ftrong Sluices, that may upon all occafions be opened and fhut. And for my part; I do not queftion but that the Proprietors themfelves in *Saumartina* would make a Chanel for it; which receiving, and confining it in the time of the Vents, might carry the Sand into the *Po* of *Primaro*: Nor need there thence be feared any ftoppage by Mud and Sand, fince that it is fupposed that there will but very feldom be any neceffity of ufing it; fo that
time

time would be allowed, upon occasion, to scowr and cleanse it.

And in this manner all those Prodigies vanish that are raised with so much fear from the entrance of the Water of *Reno* swelled into *Po*, when it is high, to which there needeth no other answer; yet nevertheless we do not take that quantity of Water, that is carried by *Reno*, and by *Panaro*, to be so great as is affirmed: For that P. D. *Benedetto Castelli* hath no lesse accurately than accurately observed the measures of this kind, noting that the breadth and depth of a River is not enough to resolve the question truly, but that there is respect to be had to the velocity of the Waters, and the term of time, things hitherto not considered, by the Skilful in these affairs; and therefore they are not able to say what quantity of Waters the said Rivers carry, nor to conclude of the risings that will follow thereupon. Nay, it is most certain, that if all the Rivers that fall into *Po*, which are above thirty, should rise at the rate that these compute *Reno* to do, an hundred feet of Banks would not suffice, and yet they have far fewer: So that this confirms the Rule of R. P. D. *Benedetto*, namely, that the proportion of the height of the Water of *Reno* in *Reno* to the height of the Water of *Reno* in *Po*, is compounded of the proportion of the breadth of the Chancel of *Po* to that of *Reno*, and of the velocity of the Water of *Reno* in *Po* to the velocity of the Water of *Reno* in *Reno*; a manifest argument that there cannot in it, by this new augmentation of Waters follow any alteration that necessitates the raising of its Banks, as appeareth by the example of *Panaro*, which hath been so far from swelling *Po*, that it hath rather asswaged it, for it hath carried away many Shelves and many Islets that had grown in its Bed, for want of Waters sufficient to bear away the matter of Land-floods in so broad a Chancel; and as is learnt by the trial made by us in *Panaro* with the Water of *Burana*; for erecting in the River standing marks, and shutting the said Sluice, we could see no sensible abatement, nor much less after we had opened it sensible increasment; by which we judge that the same is to succeed to *Po*, by letting in of *Reno*, *Burana* having greater proportion to *Panaro* than *Reno* to *Po*, considering the state of those Rivers in which the Observation was made. So that there is no longer any occasion for those great raisings of Banks, and the danger of the ruptures as well of *Reno* as of *Po* do vanish, as also the fear lest that the Sluices which empty into *Po* should receive obstruction: which if they should, yet it would be over in a few hours. And as to the Breaches of *Panaro* which happened in 1623. I know not why, seeing that it is confessed that the *Po* was not, at that time, at its height, one should rather charge it with

with the crime, than quit it thereof. The truth is, that the Bank was not made of proof, since that the same now continueth whole and good, and *Panaro* doth not break out; nay, there was, when it brake more than a foot and half of its Banks above the Water, and to spare; but it broke thorow by a Moles working; or by the hole of a Water-Rat, or some such vermine; and by occasion of the badness of the said Banks, as I finde by the testimony of some witnesses examined by my command, that I might know the truth thereof. Nor can I here forbear to say, that it would be better, if in such matters men were more candid and sincere. But to secure our selves nevertheless, to the utmost of our power, from such like Breaches which may happen at the first, by reason of the newnesse of the Banks, I presuppose that from *Po* unto the place whence *Reno* is cut, there ought to be a high and thick Fence made with its Banks, so that there would be no cause to fear any whatsoever accessions of Water, although that concurrence of three Rivers; which was by some more ingeniously aggravated than faithfully stated by that which was said above were true; to whom I think not my self bound to make any farther reply; neither to those who say that *Po* will ascend upwards into *Reno*, since that these are the same persons who would introduce a small branch of the said *Po* into the Chanel of *Ferrara*, that so it may conveigh to the Sea, not *Reno* onely, but also all the other Brooks of which we complained; and because that withal it is impossible, that a River so capacious as *Po* should be incommoded by a Torrent, that, as I may say, hath no proportion to it.

I come now to the businesse of the Ditches and Draines; and as to the Conveyance of *Burana*, it hath heretofore been debated to turn it into *Main-Po*, so that in this case it will receive no harm, and though it were not removed, yet would it by a Trench under ground pursue the course that it now holdeth, and also would be able to dis-imbogue again into the said new Chanel of *Reno*, which conforming to the superficies of the Water of *Po*, would continue at a lower level than that which *Panara* had when it came to *Ferrara*, into which *Burana* did nevertheless empty it self for some time.

The Conveyance or Drain of *Santa Bianca*, and the little Chanel of *Cento* may also empty themselves by two subterranean Trenches, without any prejudice where they run at present, or without any more works of that nature, they may be turned into the said new Chanel, although with somewhat more of inconvenience; and withall, the Chanel of *Ferrara*, left dry, would be a sufficient receptacle for any other Sewer or Drain whatsoever, that should remain there.

All

All which Operations might be brought to perfection with 150. thousand Crowns; well and faithfully laid out; which summe the *Bolognesi* will not be unwilling to provide; besides that those *Ferraresi* ought to contribute to it; who shall partake of the benefit.

Let me be permitted in this place to propose a thing which I have thought of, and which peradventure might occasion two benefits at once, although it be not wholly new. It was in the time of *Pope Paul V.* propounded by one *Crescenzi* an Engineer, to cut the *Main-Po*, above *le Papozze*; and having made a sufficient evacuation to derive the water thereof into the *Po* of *Adriano*; and so to procure it to be Navigable, which was not at that time effected, either by reason of the oppositions of those, whose possessions were to be cut thorow, or by reason of the great sum of money that was necessary for the effecting of it: But in viewing those Rivers, we have observed, that the sedge cutting might easily be made below *le Papozze*, in digging thorow the Bank called *Santa Maria*, & drawing a Trench of the bigness that skilful Artists shall judge meet unto the *Po* of *Ariano*, below the *Secche* of the said *S. Maria*; which as being a work of not above 160. Perches in length, would be finished with onely 12000. Crowns.

* Of Adriano.

First, it is to be believed, that the waters running that way, would not fail to open that Mouth into the Sea, which at present is almost choakt up by the Shelf of Sand, which the new Mouth of *Pontio Virro* hath brought thither; and that it would again bring into use the Port *Coro*, and its Navigation.

And haply experience might teach us, that the superficies of *Po* might come to fall by this asswagement of Water, so that the accession of *Reno* would questionless make no rising in it: Whereupon, if it should so fall out, those Princes would have no reason to complain; who seem to question, lest by this new accession of water into *Po*, the Sluices might be endangered. Which I thought not fit to omit to represent to your Lordship; not, that I propose it to you as a thing absolutely certain, but that you might, if you so pleased, lay it before persons whose judgements are approved in these affairs.

I return now from where I degrest, and affirm it as indubitable, that *Reno* neither can, nor ought to continue longer where it at this day is; and that it cannot go into any other place but that, whither *Cardinal Capponi* designed to carry it, and which at present pleaseth me better than any other; or into *Volana*, whence it was taken away; the vigilance of Men being able to obviate part of those mischiefs, which it may do there.

But from its Removal, besides the alleviation of the harm which

which by it self is caused, there would also result the diminution of that which is occasioned by the other Brooks, to the right hand of the *Po of Argenta*; forasmuch as the said *Po* wanting all the water of *Reno*, it would of necessity come to ebb in such manner, that the Valleys would have a greater Fall into the same, and consequently it would take in, and swallow greater abundance of water; and by this means the Ditches and Draines of the Up-Lands would likewise more easily Fall into them; especially if the scouring of *Zenzalino* were brought to perfection, by which the waters of *Marrara* would fall into *Marmotta*: And if also that of *Bastia* were enlarged, and finished, by which there might enter as much water into the said *Po of Argenta*, as is taken from it by the removal of *Reno*; although that by that means the water of the Valleys would assuage double: Nor would the people of *Argenta*, the Isles of *S. Giorgio*, and *Comacchio* have any cause to complain; for that there would not be given to them more water than was taken away: Nay sometimes whereas they had Muddy waters, they would have clear; nor need they to fear any rising: And furthermore, by this means a very great quantity of ground would be restored to culture; For the effecting of all which, the sum of 50. thousand Crowns would go very far, and would serve the turn at present touching those Brooks, carrying them a little farther in the mean time, to fill up the greater cavities of the Valleys, that we might not enter upon a vaster and harder work, that would bring with it the difficulties of other operations, and so would hinder the benefit which these people expect from the paternal charity of His Holiness.

T O
The Right Honourable,
MONSIGNORE
D. Ferrante Cesarini.



Y Treatise of the MENSURATION of RUNNING WATERS, Right Honourable, and most Noble Sir, hath not a greater Prerogative than its having been the production of the command of Pope Urban VIII. when His Holiness was pleased to enjoin me to go with *Monsignore Corsini*, in the Visitation that was imposed upon him in the year 1625. of the Waters of *Ferrara*, *Bologna*, *Romagna*, and *Romagnola*; for that, on that occasion applying my whole Study to my service and duty, I published in that Treatise some particulars till then not rightly understood and considered (that I knew) by any one; although they be in themselves most important, and of extraordinary consequence. Yet I must render thanks to Your Lordship for the honour you have done to that my Tract; but wish withal, that your Esteem of it may not prejudice the universal Esteem that the World hath of Your Honours most refined judgement.

As to that Point which I touch upon in the Conclusion, namely, That the consideration of the Velocity of Running Water suppleth the consideration of the * Length omitted in the common way of measuring Running Waters; Your Lordship having commanded me that in favour of *Practise*, and for the perfect discovery of the disorder that commonly happeneth now adays in the distribution of the Waters of Fountains, I should demonstrate that the knowledge of the Velocity serveth for the finding of the Length: I have thought fit to satisfy your Command by relating a Fable; which, if I do not deceive my self, will make out to us the truth thereof; insomuch that the rest of my Treatise shall thereby also become more manifest and intelligible, even to those

* *Larghezza*, but misprinted.

Q q q q

those who finde therein some kinde of obscurity.

In the dayes of yore, before that the admirable Art of Weaving was in use, there was found in *Persia* a vast and unvaluable Treasure, which consisted in an huge multitude of pieces of *Ermelin*, or *Damask*, I know not whether; which, as I take it, amounted to near two thousand pieces; which were of such a nature, that though their Breadth and Thickness were finite and determinate, as they use to be at this day; yet nevertheless, their Length was in a certain sense infinite, for that those two thousand pieces, day and night without ceasing, issued out with their ends at such a rate, that of each piece there issued 100. Ells a day, from a deep and dark Cave, consecrated by the Superstition of those people, to the fabulous *Arachne*. In those innocent and early times (I take it to have been, in that so much applauded and desired Golden age) it was left to the liberty of any one, to cut off of those pieces what quantity they pleased without any difficulty: But that felicity decaying and degenerating, which was altogether ignorant of *Meum* and *Tuum*; terms certainly most pernicious, the Original of all evils, and cause of all discords; there were by those people strong and vigilant Guards placed upon the Cave, who resolved to make merchandize of the Stuffs; and in this manner they began to set a price upon that inestimable Treasure, selling the propriety in those pieces to divers Merchants; to some they sold a right in one, to some in two, and to some in more. But that which was the worst of all, There was found out by the insatiable avarice of these men crafty inventions to deceive the Merchants also; who came to buy the aforesaid commodity, and to make themselves Masters, some of one some of two, and some of more ends of those pieces of stuff; and in particular, there were certain ingenuous Machines placed in the more secret places of the Cave, with which at the pleasure of the Guards; they did retard the velocity of those Stuffs, in their issuing out of the Cave; insomuch, that he who ought to have had 100. Ells of Stuff in a day, had not above 50, and he who should have had 400, enjoyed the benefit of 50. onely; and so all the rest were defrauded of their Rights, the surplussage being sold, appropriated, and shared at the will of the corrupt Officers: So that the business was without all order or justice, insomuch that the Goddess *Arachne* being displeased at those people, deprived every one of their benefit, and with a dreadful Earthquake for ever closing the mouth of the Cave, in punishment of so much impiety and malice: Nor did it avail them to excuse themselves, by saying that they allowed the Buyer the Breadth and Thickness bargained for; and that of the Length, which was infinite, there

there could no account be kept: For the wise and prudent Priest of the Sacred *Grotto* answered, That the deceit lay in the length, which they were defrauded of, in that the velocity of the stuffe was retarded, as it issued out of the Cave: and although the total length of the Piece was infinite, for that it never ceased coming forth, and so was not to be computed; yet nevertheless its length considered, part by part, as it came out of the Cave, and was bargained for, continued still finite, and might be one while greater, and another while lesser, according as the Piece was constituted in greater or lesser velocity; and he added withall, that exact Justice required, that when they sold a piece of stuff, and the propriety or dominion therein, they ought not only to have ascertained the breadth and thicknesse of the Piece, but also to have determined the length, determining its velocity.

The same disorder and confusion, that was represented in the Fable, doth come to passe in the History of the Distribution of the Waters of Conduits and Fountains, seeing that they are sold and bought, having regard only to the two Dimensions, I mean of Breadth and Height of the Mouth that dischargeth the Water; and to remedy such an inconvenience, it is necessary to determine the length in the velocity; for never shall we be able to make a guesse at the quantity of the Body of Running Water, with the two Dimensions only of Breadth and Height, without Length.

And to the end, that the whole business may be reduced to a most easie practice, by which the waters of Aqueducts may be bought and sold justly, and with measures alwayes exact and constant.

First, the quantity of the Water ought diligently to be examined, which the whole principal Pipe dischargeth in a time certain, as for instance, in an hour, in half an hour, or in a lesse interval of time, (for knowing which I have a most exact and easie Rule) and finding that the whole principal pipe dischargeth e. g. a thousand Tuns of Water in the space of one or more hours, in selling of this water, it ought not to be uttered by the ordinary and false measure, but the distribution is to be made with agreement to give and maintain to the buyer ten or twenty, or a greater number of Tuns, as the bargain shall be made, in the space of an hour, or of some other set and determinate time: And here I adde, that if I were to undertake to make such an adjustment, I would make use of a way to divide and measure the time with such accuratenesse, that the space of an hour should be divided into four, six, or eight thousand parts

Q q q q 2

with

without the least error; which Rule was taught me by my Master *Sign. Galilao Galilei*, Chief Philosopher to the most Serene *Grand Duke of Tuscany*. And this way will serve easily and admirably to our purpose and occasion; so that we shall thereby be able to know how many Quarts of Water an Aqueduct will discharge in a given time of hours, moneths, or years. And in this manner we may constitute a Cock that shall discharge a certain and determinate quantity of water in a time given.

And because daily experience shews us, that the Springs of Aqueducts do not maintain them alwayes equally high, and full of Water, but that sometimes they increase, and sometimes decrease, which accident might possibly procure some difficulty in our distribution: Therefore, to the end that all manner of scruple may be removed, I conceive that it would be convenient to provide a Cistern, according to the occasion, into which there might alwayes fall one certain quantity of water, which should not be greater than that which the principal pipe dischargeth in times of drought, when the Springs are bare of water, that so in this Cistern the water might alwayes keep at one constant height. Then to the Cistern so prepared we are to fasten the Cocks of particular persons, to whom the Water is sold by the Reverend Apostolique Chamber, according to what hath been observed before; and that quantity of Water which remaineth over and above, is to be discharged into another Cistern, in which the Cocks of the Waters for publick services, and of those which people buy upon particular occasions are to be placed. And when the businesse shall have been brought to this passe, there will likewise a remedy be found to the so many disorders that continually happen; of which, for brevity sake, I will instance in but four only, which concern both publique and private benefit, as being, in my judgment, the most enormous and intolerable.

The first inconvenience is, that in the common way of measuring, dispensing, and selling the Waters of Aqueducts, it is not understood, neither by the Buyer nor Seller, what the quantity truly is that is bought and sold; nor could I ever meet with any either Engineer or Architect, or Artist, or other that was able to decypher to me, what one, or two, or ten inches of water was. But by our above declared Rule, for dispensing the Waters of Aqueducts we may very easily know the true quantity of Water that is bought or sold, as that it is so many Tuns an hour, so many a day, so many in a year, &c.

The second disorder that happeneth, at present, in the distributing

burion of Aqueducts is, that as the businesse is now governed, it lieth in the power of a tordid Mason to take unjustly from one, and give undeservedly to another more or lesse Water, than be longeth to them of right: And I have seen it done, of my own experience. But in our way of measuring and distributing Waters, there can no fraud be committed; and putting the case that they should be committed, its an easie matter to know it, and amend it, by repairing to the Tribunal appointed.

Thirdly, it happens very often, (and we have examples thereof both antient and modern) that in dispensing the Water after the common and vulgar way; there is sometimes more Water dispended than there is in the Register, in which there will be registered, as they say, two hundred inches (for example) and there will be dispensed two hundred and fifty inches, or more. Which passage happened in the time of *Nerva* the Emperour, as *Ginlio Fromino* writes, in his 2. Book, *De Aquaductibus Urbis Romæ*, where he observeth that they had in *Commentariis* 12755. *Quinaries* of Water; and found that they dispensed 14018. *Quinaries*. And the like Errour hath continued, and is in use also modernly until our times. But if our Rule shall be observed, we shall incur no such disorder, nay there will alwayes be given to every one his share, according to the holy end of exact justice, which *dat unicuique quod suum est*. As on the contrary, it is manifest, that His Divine Majesty hateth and abominateth *Pondus & pondus, Mensura & mensura*, as the Holy Ghost speaketh by the mouth of *Solomon* in the *Proverbs*, Chap. 20. *Pondus & Pondus, Mensura & Mensura, utrumque abominabile est apud Deum*. And therefore who is it that seeth not that the way of dividing and measuring of VVaters, commonly used, is expressly against the Law of God. Since that thereby the same measure is made sometimes greater, and sometimes lesser; A disorder so enormous and execrable, that I shall take the boldness to say, that for this sole respect it ought to be condemned and prohibited likewise by human Law, which should Enact that in this business there should be employed either this our Rule, or some other that is more exquisite and practicable, whereby the measure might keep one constant and determinate tenor, as we make it, and not, as it is now, to make *Pondus & Pondus, Mensura & Mensura*.

And this is all that I had to offer to Your most Illustrious Lordship, in obedience to your commands, reserving to my self the giving of a more exact account of this my invention, when the occasion shall offer, of reducing to practice so holy, just, and necessary

necessary a reformation of the Measure of Running Waters and of Aqueducts in particular : which Rule may also be of great benefit in the division of the greater Waters to over-flow Grounds, and for other uses : I humbly bow,

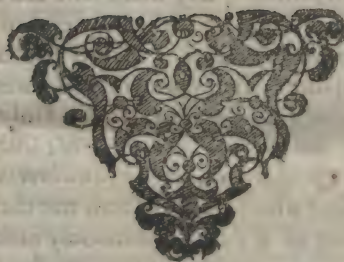
Your Most Devoted,

and

Most Obligated Servant,

D. Benedetto Castelli, *Abb. Cass.*

FINIS.



A TABLE

Of the most observable matters in this Treatise of the
MENSURATION of RUNNING
WATERS.

A

A Batements of a River in different and unequal Diversions, is alwaies equal, which is proved with 100. Syphons. Page 75
Arno River when it riseth upon a Land-Flood near the Sea one third of a Brace, is riseth about Pila 6. or 7. Braces. 82

B

Ranks near to the Sea lower, than far from thence. *Corollary XIV.* 16
Brent River diverted from the Lake of Venice, and its effects. 64
Brent supposed insufficient to remedy the inconvenience of the Lake, and the falsity of that supposition. 67
Brent, and its benefits in the Lake. 70
Its Deposition of Sand in the Lake, how great it is. 78, 79
Bridges over Rivers, and how they are to be made. *Appendix VIII.* 20
Burana River, its rising, and falling in Panaro. 110

C

Castelli applied himself to this Study by Order of Urban VIII. 2
Chanel of Navigation in the Valleys of Bologna, and its inconveniences. 99
Carried into the Po of Ferrara, and its benefits ibid.
Ciampoli a lover of these Observations of Waters. 3

D

Difficulty of this business of Measuring Waters. 2
Disorders that happen in the distribution of the Waters of Aqueducts, and their remedies. 113
Distribution of the Waters of Fountains, and Aqueducts. *Appendix X.* 22
Distribution of Water to over-flow Grounds. *Appendix XI.* 13, 69, 70
Diverſion of Reno and other Brooks of Romagna, advised by P. Spemazzati to what end it was. 100
Drains and Ditches, the benefit they receive by cutting away the Weeds and Reeds. *Appendix IX.* 21
Drains and Sewers obstructed, in the Diverſion of Reno into Main Po, and a remedy for the same. 116

E

Engineers unvers'd in the matters of Waters. 2
Errour found in the common way of Measuring Running Waters. 68, 69
Errour in deriving the Water of Acqua Paola. *Appendix II.* 17, 18

Eriow

The Table.

<i>Error of Bartolotti.</i>	86, 87
<i>Errors of Engineers in the Derivation of Channels.</i> Corollary XII.	12
<i>Error of Engineers in Measuring of Rens in Po.</i> Appendix III.	ibid.
<i>Error of other Engineers, contrary to the precedent.</i> Appendix IV.	ibid.
<i>Error of Giovanni Fontana in Measuring Waters.</i> Corollary XI.	9
<i>Error of Giulio Frontino in Measuring the Waters of Aqueducts.</i> Appendix I.	17
<i>Errors committed in cutting the Bank at Bondeno, in the swellings of Po:</i> Corollary XIII.	81

F

<i>Fenns Pontine, Drained by Pope Sixtus Quintus, with vast expence.</i>	92
<i>The ruine and miscarriage thereof.</i>	93
<i>Tardity of the principal Chanel that Drains them, cause of the Drowning.</i>	ibid.
<i>They are obstructed by the Fisking-n ears, which swell the River.</i>	94
<i>Waters of Fiume Sisto, which flow in great abundance into the Evacuator of the said Fenns.</i>	94, 95
<i>Remedies to the disorders of those Fenns.</i>	95, 96
<i>Fontana Giovanni, his errors in Measuring Waters.</i> Corollary XI.	9
<i>Fiume Morto, whether it ought to fall into the Sea, or into Serchio,</i>	79
<i>Let into Serchio and its inconveniences.</i>	79, 80
<i>The dangerous rising of its Waters, when to be expelled.</i>	81
<i>Its inconveniences when it is higher in level than Serchio, and why it riseth most on the Sea-coasts, at such time as the Winds make the Sea to swell.</i>	83

G

<i>Galilæo Galilæi, honorably mentioned.</i>	Page 2, 28
<i>His Rule for measuring the time.</i>	49

H

<i>Height, vide: Quick</i>	
<i>Heights different, made by the same stream of a Brook or Torrent, according to the divers Velocities in the entrance of the River.</i> Corollary I.	6
<i>Heights different, made by the Torrent in the River, according to the different heights of the River.</i> Corollary II.	ibid.

K

<i>Knowledge of Motion how much it importeth.</i>	1
---	---

L

<i>Lake of Perugia, and its Observation made on it.</i> Appendix XII.	42
<i>Lake of Trasimereus and Considerations upon it, a Letter written to Sig. Galilæo Galilæi.</i>	28
<i>Lake of Venice, and Considerations upon it.</i>	63, 73
<i>Low Waters which let the bottom of it be discovered.</i>	64
<i>The stoppage and clogging of the Ports, a main cause of the disorders of the Lake, and the grand remedy to those disorders what it is.</i>	66
<i>Lakes and Meers along the Sea-coasts, and the causes thereof.</i>	65
<i>Length of Waters, how it is to be Measured.</i>	70

M

<i>Measure and Distributions of Waters.</i> Appendix V.	18
	Measure

The Table.

Measure of Rivers that fall into others difficult. Coroll. X.	9
Measure of the Running Water of a Chanel of an height known by a Regulator of a Measure given, in a time assigned. Proposition I. Problem I.	50
Measure of the Water of any River, of any greatness, in a time given. Proposition V. Problem III.	60
Measure that shewes how much Water a River dischargeth in a time given.	48
Mole-holes,	
Motion the principal Subject of Philosophy.	I
Mud. Vide Sand.	

N

Navigation from Bologna to Ferrara, is become impossible, till such time as Reno be diverted.	101
Navigation in the Lake of Venice endangered, and how restored.	65, 70

P

Perpendicularity of the Banks of the River, to the upper superficies of it.	37
Perpendicularity of the Banks to the bottom.	37
Perugia. Vide Lake.	
Pontine. Vide Fenns.	
Port of Venice, Malamocco, Bondolo, and Chiozza, choaked up for want of Water in the Lake.	65
Proportions of unequal Sections of equal Velocity, and of equal Sections of unequal Velocity. Axiome IV. and V.	38
Proportions of equal and unequal quantities of Water, which pass by the Sections of different Rivers. Proposition II.	39
Proportions of unequal Sections that in equal times discharge equal quantities of Water. Proposition III.	41
Proportion wherewith one River falling into another, varieth in height. Proposition IV.	44
Proportion of the Water discharged by a River in the time of Flood, to the Water discharged in an equal time by the said River, before or after the Flood. Proposition V.	44
Proportion of the Heights made by two equal Brooks or Streams falling into the same River. Proposition VI.	45
Proportion of the Water which a River dischargeth encreasing in Quick-height by the addition of new Water, to that which it dischargeth after the encrease is made. Proposition IV. Theor. II.	54
Proportion of a River when high, to it self when low. Coroll. I.	55

Q

Quantity of Running Waters is never certain, if with the Vulgar way of Measuring them, their Velocities be not considered.	32
Quantities of Waters which are discharged by a River, answer in equality to the Velocities and times in which they are discharged. Axiome I, II, III.	38
Quick-Height of a River, what it is. Definition V.	48

R

Reason of the Proverb, Take heed of the still Waters. Coroll. VI.	7
Reasons of Monsignore Corsini against the diversion of Reno into the Po of Volano.	105
Reasons of Cardinal Capponi and Monfig. Corsini, for the turning of Reno into Main Po.	106

Rrrr

Red

The Table.

Two objections on the contrary, and answers to them.	104 & 105
What ought to be the proportion of the Heights of Reno in Reno, and of Reno in Po.	110
Regulator what it is. Definition IV.	48
Relation of the Waters of Bologna and Ferrara, by Monsignore Corfini	100
Reno in the Valleys, and its bad effects.	100, 101
Two ways to divert it.	103
The facility and utility of those ways.	Ibid.
The difficulties objected.	104
Reply to Bartolotti touching the dangers of turning Fiume Morto into Serchio.	83
Retardment of the course of a River caused by its Banks. Appendix VII.	19
Risings made by Flood-Gates but small. Appendix XIII.	26
Rivers that are shallow swell much upon small showers, such as are deep rise but little upon great Floods. Corollary III.	6
Rivers the higher they are, the swifter.	Ibid.
Rivers the higher they are, the less they encrease upon Floods.	49
Rivers when they are to have equal and when like Velocity.	Ibid.
Rivers in falling into the Sea, form a shelf of Sand called Cavallo.	65
Five Rivers to be diverted from the Lake of Venice, and the inconveniences that would ensue thereupon.	74, 75
A River of Quick-sight, and Velocity in its Regulator being given, if the Height be redoubled by new Water, it redoubleth also in Velocity. Proposition II. Theorem I.	51
Keepeth the proportion of the heights, to the Velocities. Corollary	52

S

Sand and Mud that entereth into the Lake of Venice, and the ways to examine it.	76
Seas agitated and driven by the Winds stop up the Ports.	64, 65
Sections of a River what they are. Definition I.	37
Sections equally swift what they are. Definition II.	Ibid.
Sections of a River being given, to conceive others equal to them, of different breadth, height and Velocity. Petition.	38
Sections of the same River, and their Proportions to their Velocities. Coroll. I.	42
Sections of a River discharge in any whatsoever place of the said River, equal quantities of Water in equal times. Proposition I.	39
Sile River what mischiefs it threateth, diverted from the Lake.	74
Springs of Waters grow bigger the higher they go. Coroll. XVI.	16
Streams of Rivers how they encrease and vary. Coroll. I.	6
Streams retarded, and the effects thereof. Coroll. IX.	8

T

Table of the Heights, Additions, and Quantities of Waters, and its use.	56
Thorsmeaus. Vide Lake.	
Time how its measured in these Operations of the Waters.	49
Torrents encrease at the encreasing of a River, though they carry no more Water than before. Coroll. IV.	6
Torrents when they depose and carry away the Sand. Coroll. V.	7
Torrents and their effects in a River.	6, 7
Torrents that fall into the Valleys, or into Po of Volano, and their mischiefs prevented, by the diverting of Reno into Main Po.	100
Tyber and the causes of its inundations. Coroll. VIII.	8

Val-

The Table.

V

<i>Valleys of Bologna and Ferrara, their inundations and disorders; whence they proceed.</i>	97
<i>Velocity of the Water shewn by several Examples.</i>	3
<i>Its proportion to the Measure.</i>	5
<i>Velocities equal, what they are.</i>	47
<i>Velocities like, what they are.</i>	47, 48
<i>Velocities of Water known, how they help us in finding the Lengths.</i>	113
<i>A Fable to explain the truth thereof.</i>	Ibid.
<i>Venice. Vide Lake.</i>	
<i>Use of the Regulator in measuring great Rivers. Consideration I.</i>	60

W

<i>Waters falling, why they disperse. Coroll. XVI.</i>	16
<i>Waters, how the Length of them is Measured.</i>	70
<i>Waters that are employed to flow Grounds, how they are to be distributed.</i>	19, 53, 54
<i>Waters to be carried in Pipes, to serve Aquaducts and Conduits, how they are to be Measured.</i>	115, 116
<i>Way to know the rising of Lakes by Raines.</i>	28
<i>Way of the Vulgar to Measure the Waters of Rivers.</i>	68
<i>Wind Gun, and Portable Fountain of Vincenzo Vincenti of Urbin.</i>	11
<i>Winds contrary, retard, and make Rivers encrease. Coroll. VII.</i>	8

The END of the TABLE of the Second Part
of the First TOME.

V

W

